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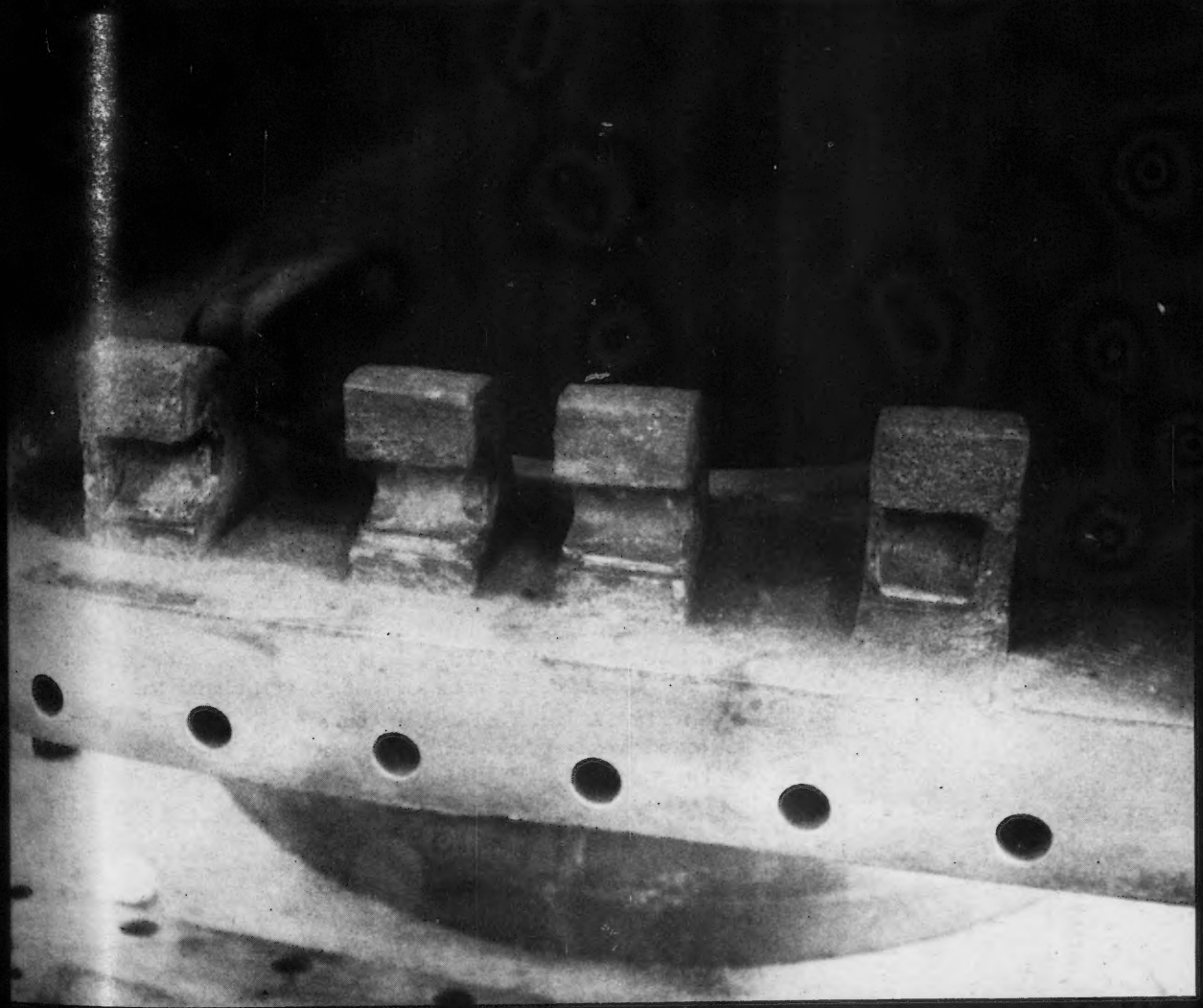

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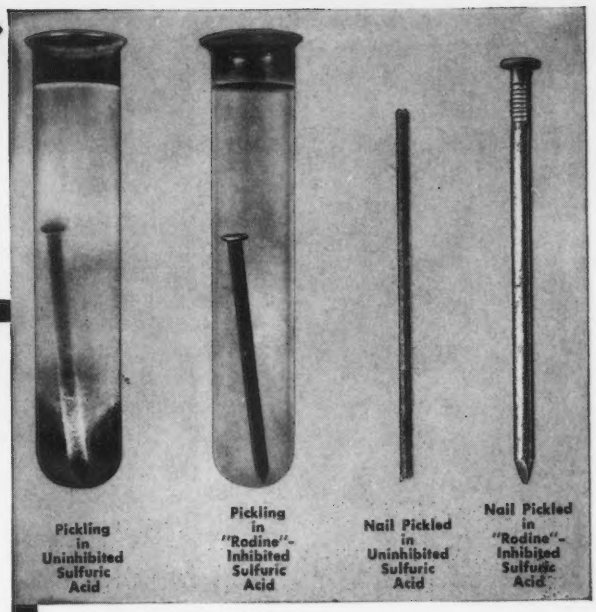
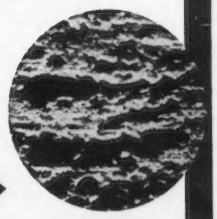

Pickling in Uninhibited Sulfuric Acid
Pickling in "Rodine"-Inhibited Sulfuric Acid
Nail Pickled in Uninhibited Sulfuric Acid
Nail Pickled in "Rodine"-Inhibited Sulfuric Acid

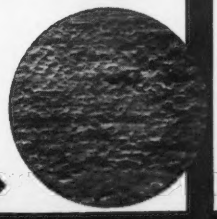
The photographs above illustrate the beneficial effect produced by a small amount of "Rodine" in a pickle bath.

A. Both test tubes contain a 10 per cent by volume solution of sulfuric acid. In the left-hand tube, no further additions have been made to the acid. Notice the gas bubbling off the nail. This is hydrogen, caused by the action of acid on good metal. In the right-hand tube, "Rodine" has been added in an amount equal to 1 per cent by volume of the concentrated acid. Notice the absence of bubbling in this tube. "Rodine" prevents the formation of hydrogen that results from dissolving metal.

B. Both nails after being pickled for the same time. The nail pickled with "Rodine" has lost little weight and has retained its original luster and appearance. The nail pickled without "Rodine" is no longer a nail. "Rodine" prevents the acid from dissolving metal.



This steel surface was pickled in an uninhibited acid bath. Note the deep pits, and that the surface is visibly crystalline.



This surface was pickled exactly like the one above except that "RODINE" was added to the acid solution. Only scale pockets and roll marks are visible; no pitting occurred.

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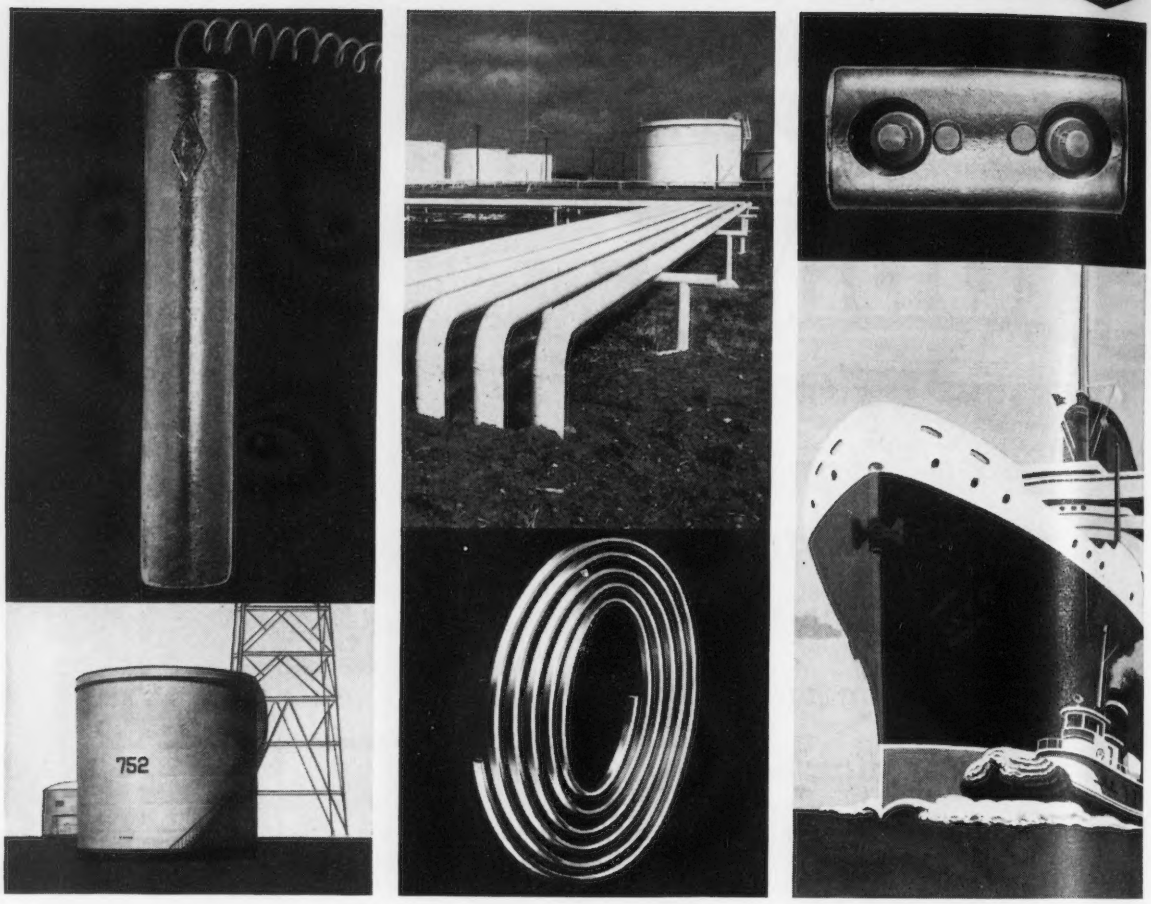

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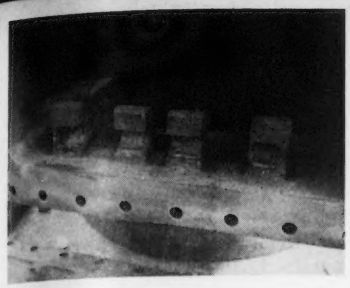

THIS MONTH'S COVER—When the babbitt bearings on this aqueduct valve failed a $22,000,000 aqueduct was shut down for several days so repairs could be made. Galvanic corrosion between the babbitt and a bronze shaft caused the damage. More information on this valve may be found in the Technical Committee News section of this issue.

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research and control

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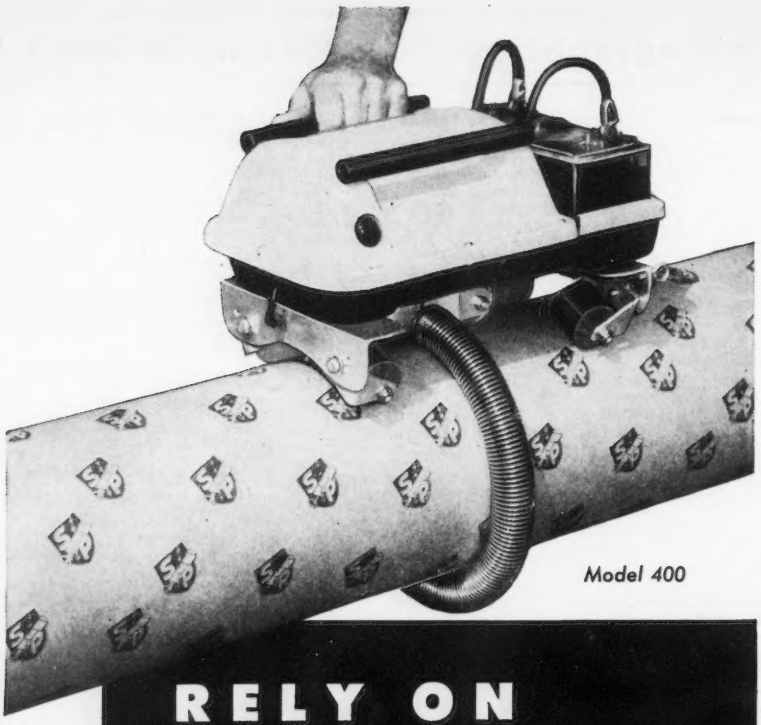
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Annually, in December issue, a cross-referenced tabular topical index of the material published in the Technical Section is published. An alphabetical subject index will be published in the December, 1954, issue.

Annually, in December issue, an alphabetical author index is published.

Annually, in December, a tabular index to the Corrosion Abstract Section is published.

Monthly, technical articles published in Corrosion are abstracted in the Corrosion Abstract Punch Card Service.

5 Year Index, 1945-49, consisting of a cross-referenced tabular topical index and an alphabetical author index was published in the December, 1950, issue of Corrosion.

Bibliographic Surveys of Corrosion—Corrosion Technical Material is indexed in the NACE's Bibliographic Surveys.

Corrosion is regularly indexed by Engineering Index.

10-year Index, 1945-54—In preparation and scheduled to appear early in 1955 is a 10-year index to the Technical Material published in Corrosion. It will consist of an alphabetical subject index and an alphabetical author index.

No indices of other sections of Corrosion are prepared by NACE.

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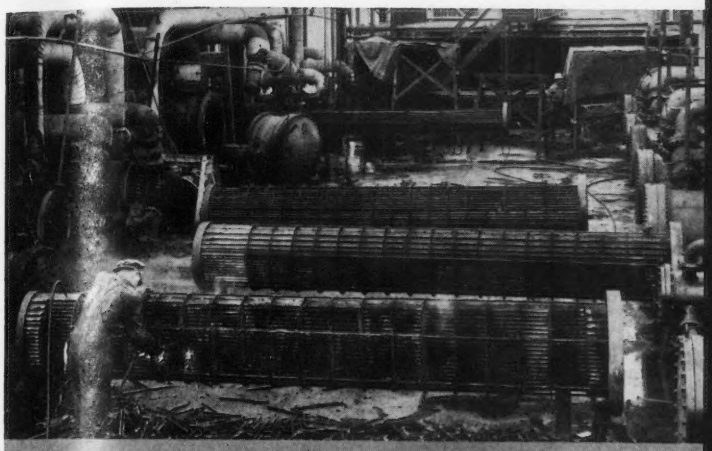

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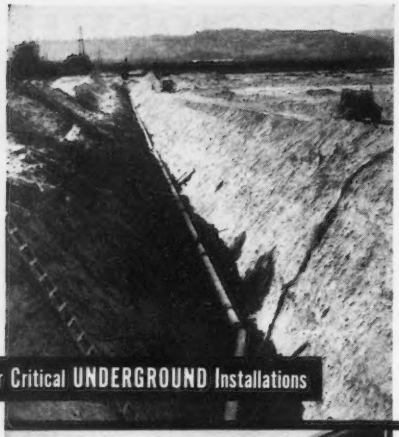

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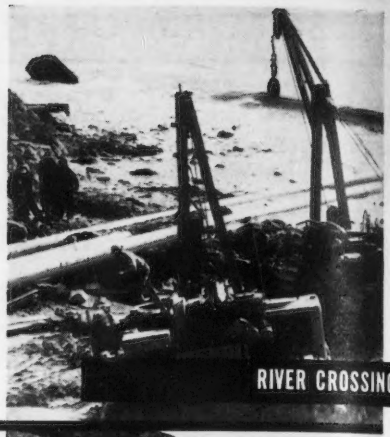

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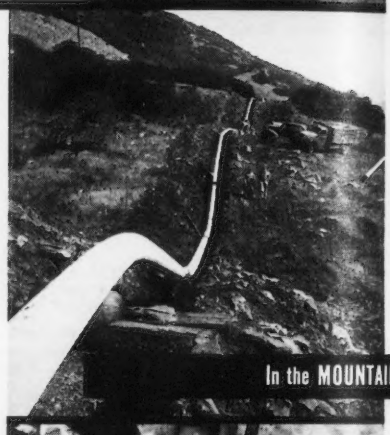

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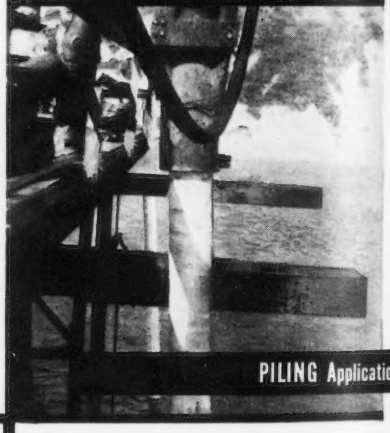

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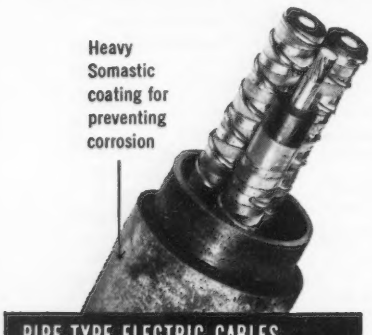

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Comparison of resistance to corrosion. This photograph of tubing subjected to corrosion by gas condensate in the petroleum industry shows (left) condition of internally nickel plated section after 18 months' service, and (right) bare steel tubing in service for 12 months. (Photographs courtesy of Bart Manufacturing Co., Bellville, N. J.)

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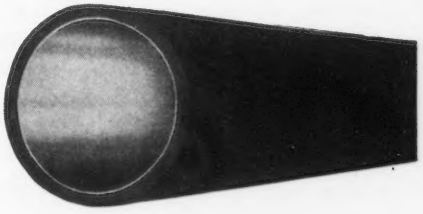

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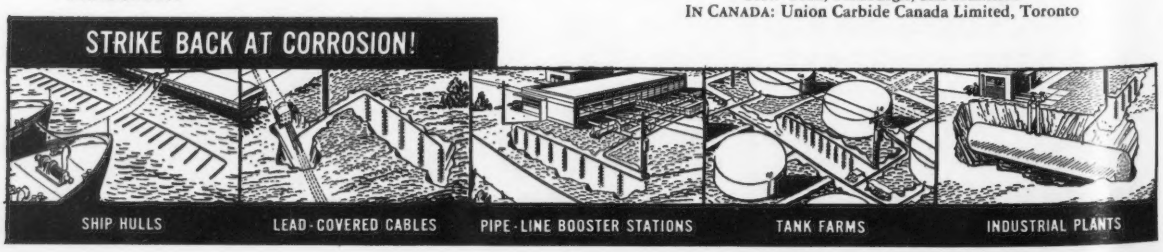

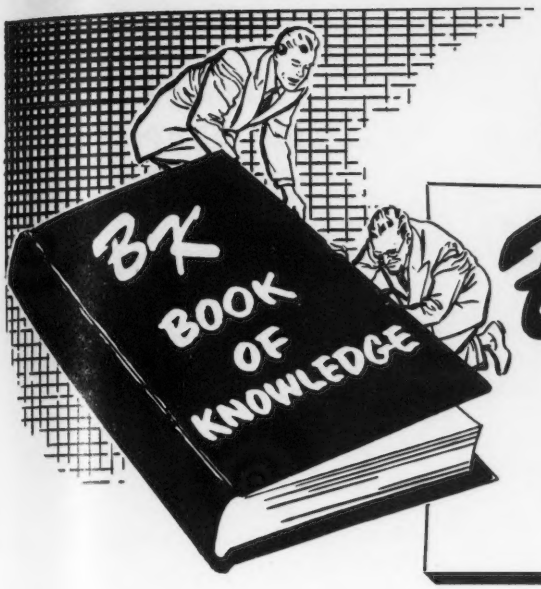

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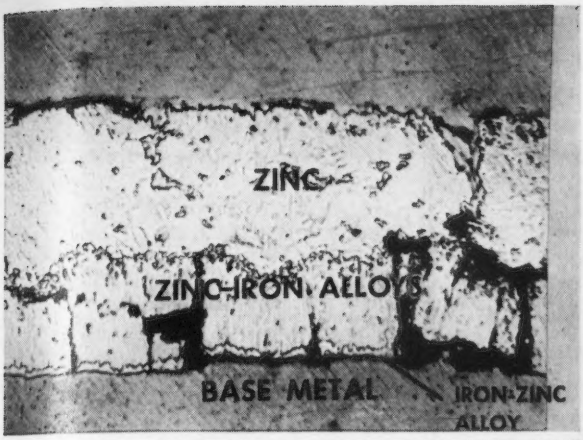
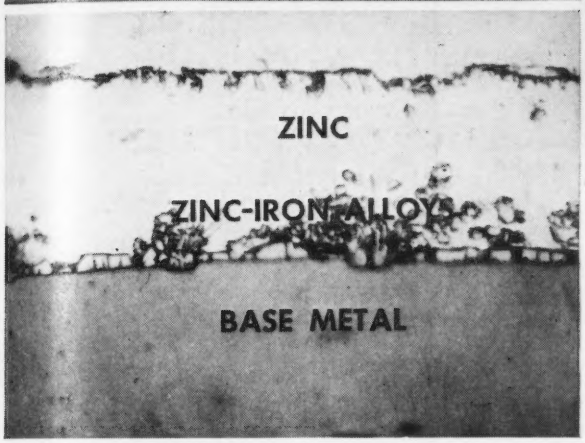


OLD Cross-section of the old type coating after the metal was stretched only 15%. Dark areas are cracks that spread from the brittle alloy layer, causing the coating to flake or peel off.

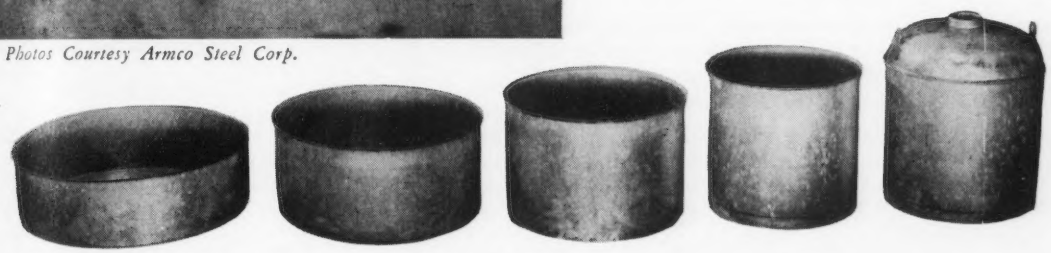
IN GALVANIZED STEEL... *a new look*



NEW Cross-section of the new type coating after 20% stretching. There is no brittle alloy layer and the zinc coating adheres tightly to the base metal.

WHAT CAN BE DONE This container, made of hot dipped galvanized steel, started as a 26⅛ in. dia. circular blank. Finished product, after four draws, is 11¼ in. in dia. and 10½ in. deep.

Photos Courtesy Armco Steel Corp.



THE CHIEF FUNCTION OF ZINC — the most generally available metal which is electro-negative to iron — is the rust-proofing of iron and steel products. Since a zinc coating provides the ferrous base with perfect electrolytic protection against rust, it is not surprising that for many years the galvanizing industry has used nearly one half of all the zinc consumed annually in the United States.

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The improved properties of the continuous line product have led to a much broader application of galvanized sheet and strip. Coated with zinc, they have the most flexible and versatile protective surface obtainable, and the outlook is one of ever-widening application.

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(b) To provide forums and media through which experiences with corrosion and its prevention may be reported, discussed and published for the common good.

(c) To encourage special study and research to determine the fundamental causes of corrosion, and to develop new or improved techniques for its prevention.

(d) To correlate study and research on corrosion problems among technical associations to reduce duplication and increase efficiency.

(e) To promote standardization of terminology, techniques, equipment and design in corrosion control.

(f) To contribute to industrial and public safety by promoting the prevention of corrosion as a cause of accidents.

(g) To foster cooperation between individual operators of metallic plant and structures in the joint solution of common corrosion problems.

(h) To invite a wide diversity of membership, thereby insuring reciprocal benefits between industries and governmental groups as well as between individuals and corporations.

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Corrosion

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An Association of Individuals and Organizations Concerned with Control of Corrosion

1061 M & M Building Houston 2, Texas

Vol. 10 August, 1954 No. 8

Topic of the Month

A Method of Protecting Heating Coils In Some Corrosive Solutions

By G. G. SCHMUCK* and R. W. FLOURNOY**

COILS for heating corrosive solutions frequently are subjected to more drastic changes in temperature, thermal stress and agitation than tanks, pipe lines and other equipment. Furthermore many of the materials available for heat exchangers are fragile, others extremely expensive and the remainder restricted in their applications. It is difficult, therefore to find an economical material for heating coils which can be used in severely corrosive solutions.

One solution that has been proved satisfactory in numerous applications is the application of a coating of fluorocarbon plastic material to common metals. Two of these plastics are resistant to many corrosives at temperatures up to 400 degrees F. The monochlorotrifluoroethylene polymer, for example, has been applied in coatings up to 0.020-inch free of pinholes and flaws. Steam or other heating media may be used which are not corrosive to the unprotected interiors of pipes so coated.

Figure 1 shows an aluminum heating coil coated with monochlorotrifluoroethylene polymer. First coils of this type were coated only 0.005-inch, but the plastic was increased in thickness to 0.020 to extend the useful life of the coil. Coatings of both thicknesses have been tested with a 30,000-volt spark and found to be free of flaws.

While the coating reduces the heat transfer efficiency, the loss is not great enough to be significant in many applications.

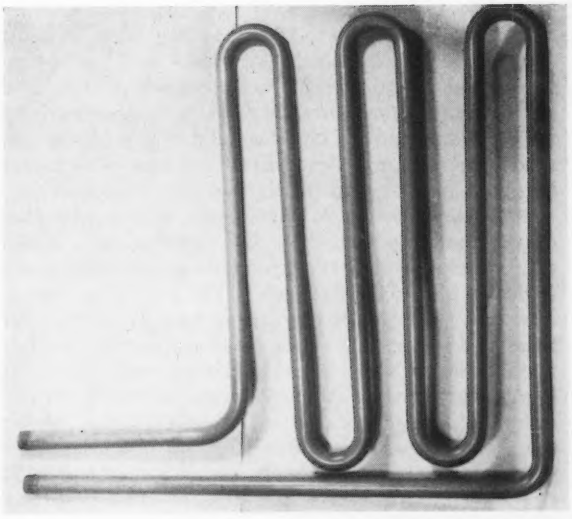

Figure 1—Aluminum heating coil coated with monotrichlorofluoroethylene polymer for use in corrosive solutions.

The coatings may be applied also to other designs of heaters. While the life of this type of construction is limited it still is greater than that of competitive heating equipment for some critical heating problems.

* Permaline Rubber Products Co., Chicago.
** Corn Products Refining Co., Argo, Ill.

NACE TECHNICAL COMMITTEE REPORTS

Publication 54-2

A Report of T-2C on Minimum Current Requirements for Cathodic Protection

Some Observations of Cathodic Protection Potential Criteria in Localized Pitting*

Introduction

THOSE ENGAGED in the application of cathodic protection to buried or submerged metallic structures are often concerned with the real significance of their measurements of the structure potentials. There is considerable evidence[1] which indicates that lowering the potential of iron to —0.77 volts measured against a saturated KCl calomel reference electrode (equivalent to —0.85 volts measured against a Cu-$CuSO_4$ reference electrode) will provide protection. Yet, experience has not yielded a specification for a potential measurement technique whereby the observation of this protective potential value will be assurance that the optimum protective condition exists.

The absence of a universally accepted potential measuring technique for protective criteria suggest that there are many factors which affect the potential "seen" by the reference electrode. Since localized pitting is usually the most damaging form of metal destruction observed on pipelines and submerged structures, an idealized cell consisting of a small anode area centered in a large cathode plane area has been constructed to facilitate the study of the geometric, corrosion environment and electrical factors involved in cathodic protection potential criteria.

It is the purpose of this report to describe some experiments made to show the significance of potentials measured at several predetermined positions in front of the model cell when the corrosion current flow has been stopped by an applied protective current. The importance of the corroding media resistivity upon the potentials observed is demonstrated. An attempt is made to correlate the conventional electrical circuitry found in a cathodically protected corrosion system with the spatial distribution of the potential measured in the corroding media. Other general observations pertinent to the application of cathodic protection are described.

It is felt that in a study of the following data a position should be taken that:

a. Although the experimental cell is not truly representative, it does include the basic spatial, environmental and electrical elements found in localized pitting and the phenomena observed exists—to a greater or lesser extent—in actual corroding systems.

Summary

In order to help understand the meaning of potential measurements protective current was applied to a model cell including the basic spatial, electrical and environment factors found in localized pitting. Corroding medias having a specific resistivity of 15-22,000 ohm-cm and 160 ohm-cm were used in the experiments.

The open circuit potentials of the anode and cathode elements including that of mill scale were observed. Equipotential lines measured in the corroding media are graphically shown for the coupled pitting system.

Equipotential lines are also graphically shown when protective current was applied and the corrosion current flow from the pit had ceased. It is noted that the equipotential line corresponding to the open circuit potential of the anode, is located at some distance from the cathode. The DC null potential measurement technique was used to observe any relation between a break in the pot.-log current relation and the flow of corrosion current in the pit.

The following observations seem to have support:

1. The potential measurement of the cathodically protected structure should include all the IR drop form characteristic of polarization resulting from the flow of the protective current through the cathode resistive element. The latter resistive element includes the cathode surface resistance plus the resistance of the electrolytic cell adjoining the cathode surface.
   a. The boundary of the cathode electrolytic resistive element at which the reference electrode should be positioned seems to be determined by the size and spatial positions of the anode and cathode of the corroding system. The smaller the anode the closer the reference electrode should be placed to the structure.
   b. The location of the reference electrode becomes more important as the environment resistivity increases.
2. The ratio of protective current required to corrosion current increases with increasing media resistivity.
3. Mill scale can be more cathodic than copper.

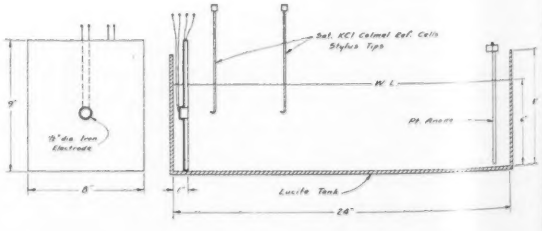

Figure 1—Copper-iron couple representing local pitting cell details. Note: Iron anode insulated from ¼-inch copper cathode plate. Back of copper plate and iron anode are coated. Reference cells are movable.

★A report prepared by L. P. Sudrabin, Electro Rust-Proofing Corp., Belleville, N. J., chairman T-2C.

b. The observations are not translatable directly to an exact procedure in practice but they should be helpful in better understanding the meaning of a potential measurement when the procedure for making such a measurement has been carefully defined.

Procedure

The cell used to illustrate the nature of localized pitting and the response to applied protective current was constructed as shown in Figure 1. The pitting area of this cell was a polished ½-inch diameter iron rod placed near the center of a 8 x 9 x ¼-inch copper plate. The iron (anode) was insulated from the copper (cathode) plate and the back of the cell assembly was coated, leaving only the front exposed to the corroding media. Two test leads were attached to each electrode to facilitate measurement of current and potential by means of the circuits shown in Figures 4A and 4B.

The model cell was placed in a Lucite tank 8 x 8 x 24-inches containing the corroding media. The protective current could be applied from a) a length of platinum 29 wire placed at the opposite end of the tank (remote anode) or b) a ¼-inch diameter iron disk placed one centimeter in front of the pitting area.

The potential measurements were made against saturated KCl calomel reference electrodes with stylus tips. The tips of these reference electrodes were movable along the horizontal plane at the elevation of the ½-inch diameter iron anode. Positions for potential measurements were established by aligning the reference electrode tip with the intercept of lines normal to the cell face from points a, b, c, d, e, f and g shown in Figures 2A and 3A and lines through points located at one centimeter intervals on the sides of the lucite tank in front of the cell.

In order to compare the open circuit potential of the copper plate with mill scale a piece of mill scale taken from an ingot of iron was immersed in the corroding electrolyte.

Tests were repeated in high and low resistivity medias, respectively a) Belleville, N. J. tap water (with a specific resistivity decreasing from 22,000 to 15,000 ohm-cm as the tests progressed because of salt leaching from the stylus tips of the reference electrodes) and in b) the same tap water to which NaCl had been added until a specific resistivity of 160 ohm-cm was reached.

Open Circuit Potentials

In each of the two corroding medias the open circuit potential of the ½-inch diameter iron, the copper plate and the mill scale were measured against a reference electrode.

Freely Corroding

In each of the two medias the corrosion current was measured when the iron and copper electrodes were coupled by closing switch S_3 and observing meter i_a in Figure 4A. Potentials were measured at

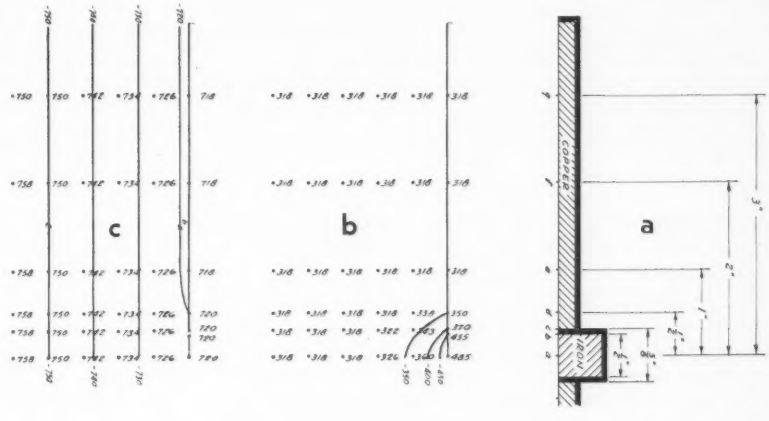

Figure 2—Equipotential lines (unprotected and protected) copper-iron couple. Electrolyte, Belleville, N. J. tap water plus NaCl. ρ — 160Ω — cm.

b) Corrosion (Local cell). $i_a = i_c = i_l = 3.2$ma.

Open circuit $E'_a = -720$ ma
$E'_c = -165$ mv
$E_{millscale} = -080$ mv

c) Cathodic protection. $i_a = O_{ma}$. $I_p = 9.8$ ma.

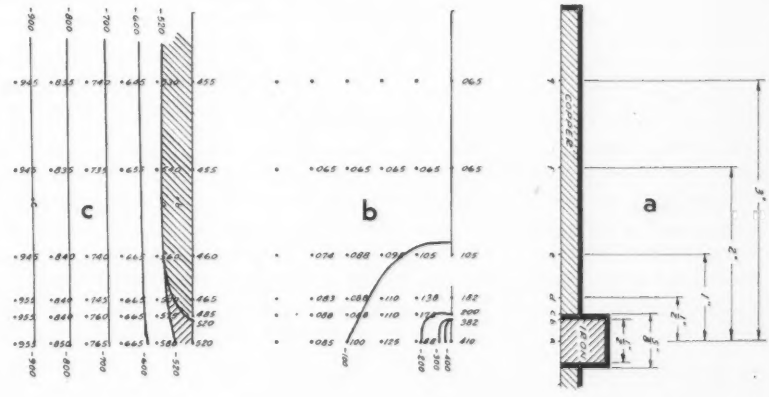

Figure 3—Equipotential lines (unprotected and protected) copper-iron couple. Electrolyte, Belleville, N. J. tap water. ρ — 15 — 22,000Ω — cm.

b) Corrosion (local cell). $i_a = i_c = i_l = 61$ ma.

Open circuit $E'_a = -520$ mv
$E'_c = -002$ mv
$E_{millscale} = +010$ mv

c) Cathode protection. $i_a = O\mu_a$. $I\rho - 1.95$ ma. By definition: Cathodic protection is complete when cathode is polarized to the open circuit potential of the anode. $E'_a = E_c + I_p\ (R_{c_f} + R_{K_c}\rho)$.

Note: a. $E'_a = -520$ mv
b. The cathodic polarization includes $I\rho\ R_{Kcp}$ potential drops shown *in* hatched section.

the metal surface and at predetermined locations in the corroding media.

Cathodic Protection

Protective current was applied in each of the corroding medias from the platinum anode until the net corrosion current flowing out of the anode $i_a = o$. The protective current was observed and the potentials were measured against a reference electrode at predetermined locations in the corroding media.

The protective current I_p required, to limit the corrosion current $i_a = o$ from the ¼-inch diameter anode disk temporarily positioned one centimeter in front of the iron electrode of the model cell was measured.

The Pearson DC null circuit technique was used to determine the relationship of any observed break in the plotted data of potential vs. log protection current upon the corrosion current flow.

Fundamentals

The circuit relationship of the electrical elements of potentials, resistance and current found in natural corrosion and in a cathodic protection system are shown in Figure 4A. This circuitry is adapted largely from a lecture presented by J. M. Pearson at the Massachusetts Institute of Technology Summer Corrosion Course in 1951 and other work reported by Pearson,[2] Holler[3] and Brown and English.[4] The concept is expanded by recognizing that the resistance effect through the electrolyte contiguous to the anode and cathode must be included. The resistance cell constants $R_{k_a}\rho$ and $R_{k_c}\rho$ of the anode and cathode electrolyte, respectively, are a function of both size and spatial positioning of the electrodes and the resistivity of the electrolyte.

The electrical elements within the corrosion and cathodic protective system are:

E_a — anode potential (closed circuit)
E_c — cathode potential (closed circuit)
i_a — anode current
i_c — cathode current
R_{a_f} — resistance (anode surface)
$R_{k_a}\rho$ — resistance (electrolyte contiguous with anode)
R_{c_f} — resistance (cathode surface)
$R_{k_c}\rho$ — resistance (electrolyte contiguous with cathode)
R_x — resistance of electrolyte outside boundary of corrosion cell
i_l — local action current
I_p — protective current

By use of Kirchoff's Laws the following relations are developed for the circuit containing the local cell elements:

$$-E_a + E_c + i_a (R_{a_f} + R_{k_a}\rho) + i_c (R_{c_f} + R_{k_c}\rho) = 0 \quad (1$$

The current flow out of the anode (i_a) into the cathode (i_c) and local action current (i_l) are equal.

$$i_a = i_c = i_l = \frac{E_a - E_c}{(R_{a_f} + R_{k_a}\rho) + (R_{c_f} + R_{k_c}\rho)} \quad (2$$

When protection is applied the sum of the currents leaving and entering a junction is zero.

$$+ i_c - i_a - I_p = 0 \quad (3$$

By rearranging equation 1 and 3 and solving simultaneously the effect of the protective current I_p upon the corrosion current flowing out of the anode i_a can be shown.

4) $i_a (R_{a_f} + R_{k_a}\rho) + i_c (R_{c_f} + R_{k_c}\rho) = -E_c + E_a$] x1
5) $-i_a + i_c = I_p$] x $-(R_{c_f} + R_{k_c}\rho)$

6) $$i_a (R_{a_f} + R_{k_a}\rho + R_{c_f} + R_{k_c}\rho) = E_a - E_c - I_p (R_{c_f} + R_{k_c}\rho)$$

7) $$i_a = \frac{E_a - E_c}{(R_{a_f} + R_{k_a}\rho + R_{c_f} + R_{k_c}\rho)} - \frac{(R_{c_f} + R_{k_c}\rho) I_p}{(R_{a_f} + R_{k_a}\rho + R_{c_f} + R_{k_c}\rho)}$$

By definition[5] cathodic protection is complete when $i_a = o$ and/or the cathode of the corroding system is polarized to the open circuit potential of the anode E'_a.

The protective potential E'_a may be expressed:

$$E'_a = E_c + I_p (R_{c_f} + R_{k_a}\rho) \quad (8$$

The equations 6 and 7 may not hold absolutely true because the resistive elements $R_{k_a}\rho$ and $R_{k_c}\rho$ can vary in value when considered in the local action current flow between two electrodes and then in their effect upon current flow from an auxiliary anode. It is felt the variance is not sufficient to disturb the thinking developed in this report greatly.

Throughout the development in this report the term "polarization" includes three mechanisms.[8]

1. The production of counter-emf by products formed or by concentration changes resulting from passage of current through an electrolytic cell.[9]
2. The IR drop effects between the electrode and the electrolytic cell boundary expressed in terms of an emf.
3. An activation potential required to drive an appreciable current through the interface where the electrode reactions may be inherently slow.

Observations

1. The potentials of the uncoupled ½-inch diameter iron electrode, copper plate and the piece of mill scale were measured separately against the reference electrode after the potentials had stabilized to change of less than one millivolt per minute. The values observed are shown in Table 1.

At the International Nickel Co., Inc. Harbor Island Test Station the potential of the mill scale in quiet sea water was measured to be in the range of ± 25 mv.

2. The ½-inch diameter iron electrode was then coupled to the copper plate and allowed to stabilize until the potential measured against reference electrode 3 inches in front of the cell changed less than one millivolt per minute. This was done first in water having a specific resistance of 15-22,000 ohm-cm and then in the 160 ohm-cm water.

The freely corroding current and the potential measurements are tabulated and shown graphically

in Figure 2B (Low Resistivity Media) and Figure 3B (High Resistivity Media).

3. The protective current I_p required to stop the flow of corrosion current i_a from the ½-inch diameter iron electrode and the potentials measured in the electrolyte are tabulated and shown graphically in Figure 2C (Low Resistivity Media) and Figure 3C (High Resistivity Media). The equipotential line equal to the open circuit potential of the ½-inch diameter steel electrode when $i_a = o$ was determined separately and is shown in Figures 2C and 3C.

4. The protective current I_p requirements to stop the corrosion current $i_a = o$, applied from the remote platinum anode and the ¼-inch diameter disk anode placed one centimeter in front of the ½-inch diameter steel electrode, respectively, are shown in Table 2 for High and Low Resistivity Medias.

5. The effect of increasing amounts of protective current applied from a platinum anode (remote) upon the corrosion current i_a flow out of the iron electrode is shown in Figure 5.

6. The potential of the localized pitting cell model, was measured by means of the Pearson DC null circuit (shown in Figure 4B) with increasing amounts of protective current I_p applied from the platinum anode. In this technique the potentials observed do not include the IR drop effects resulting from the protective current I_p flow through the resistance in any of the electrolyte R_x and the resistance elements of the local cell.

In one high resistivity medium the break observed in the potential-current or potential-log current relationship was not associable with the protective current I_p required to limit the corrosion current flow $i_a = o$.

A break observed in the potential-log current relationship was more closely related to the protective current I_p requirements to stop the corrosion current ($i_a = o$) in the low resistivity media.

Discussion

The use of a model corrosion cell representing local pitting action, with applied protective current, has been helpful in demonstrating the importance of certain spatial, environmental and electrical factors upon cathodic protection criteria. In the example used, where the anodic area is small compared to the cathodic area, the freely corroding system is found to be under an apparent mixed anodic and cathodic control.[6] The potential observed outside the boundary

TABLE 1.

Open circuit potentials vs calomel reference electrode

Media Resistivity	½" Diam. Iron	Copper Plate	Mill Scale
15-22,000 ohm cm	—520 mv	— 2 mv	+10 mv
160 ohm cm	—720 mv	—165 mv	—80 mv

TABLE 2

Protective Current I_p required to make corrosion current $i_a = o$.

Media Resistivity	Platinum Anode (Remote)	¼" Disk Anode (Close)
15-22,000 ohm cm	5.2 ma	0.48 ma
160 ohm cm	8.2 ma	6.5 ma

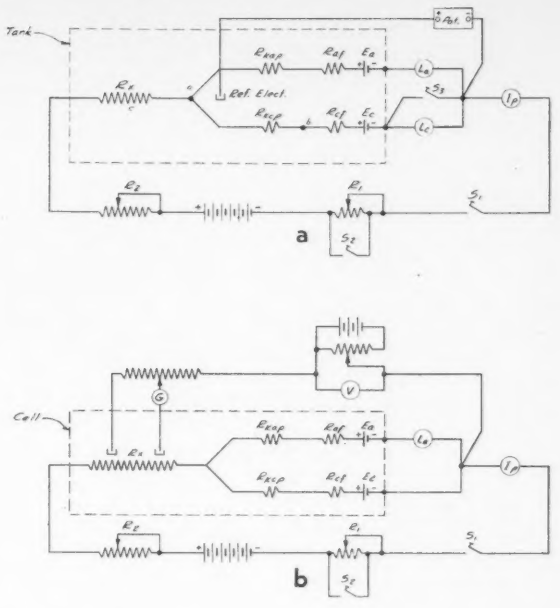

Figure 4—a) Corrosion and cathodic protection circuit. b) Pearson DC null circuit.

of the currents lay between the anode and cathode open circuit potentials. This situation usually exists in well aerated high resistivity soils and water.

It is also noted that the open circuit potential of the ½-inch diameter iron electrode does not correspond to the potential of an active anode.[1] Though the corrosion current flow $i_a = o$ from the model pit to the copper plate (Figure 3C and 4C), some current will continue to flow locally on the surface of the iron electrode until the potential close to its surface has been lowered to —0.77 volts measured against the calomel reference electrode.

Through consideration a) of the relationship between the electrical elements found in a corrosion system when a protective current is applied as shown in Figure 4A and expressed in Equations 1 through 8; b) the resultant equipotential lines of the local action cell Figure 2B, 2C and Figure 3B, 3C; c) the relationship between the corrosion current i_a and the protective current I_p in Figure 5 and the other pertinent data shown, the following generalizations on protective criteria appear to have support.

1. In measuring the potential of cathodically protected metal, the reference electrode should be positioned so that the IR drop effect resulting from the flow of a protective current I_p thru the electrolytic cell component ($R_{x_c}\rho$) is included in the cathodic polarization. The importance of this is shown by the reference electrode position at points a, b, and c in Figure 3C.

   a. A reference electrode positioned at point a along equipotential line (—520 mv), for the corrosion cell shown, includes all the resistive elements ($R_{ef} + R_{x_c}\rho$) in the cathode cell element of the fully protected system.

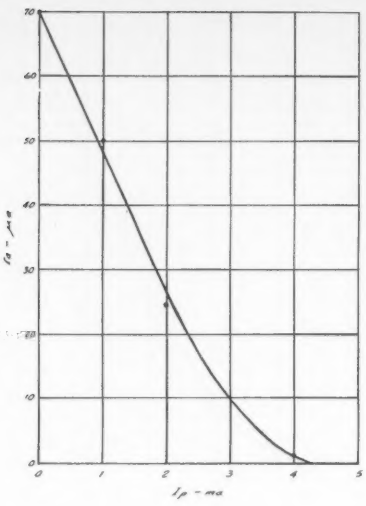

Figure 5—Copper-iron couple—local pitting. Corrosion current I_a. Protective current I_p.

b. An electrode positioned at point b will not include all of the element $R_{k_c\rho}$. Observing the open circuit potential E'_a at this point will result in over protection.

c. An electrode positioned at point c will include all the resistive effect of $(R_{c_f} + R_{k_c\rho})$ plus the effect of some of R_x outside the boundary of the fully protected system. A potential E'_a measured at point c will result in underprotection.

The reference electrode positions a, b and c for potential measurement are related to the electrical elements of a protected corrosion system as shown in Figure 4A.

2. Since the resistance elements R_x and $R_{k_c\rho}$ are a function of the soil or water resistivity the importance of proper electrode position is emphasized with increasing resistivities. Compare the values of the equipotential lines in Figure 2C and Figure 3C.

3. The boundary of the cathode cell component $R_{k_c\rho}$ seems to be related to the dimensions and the spatial relationship of the corroding anode to the cathode. In the model cell having an anode ½ inch in diameter, the boundary appears to be about ⅜-inch away from the metal surface. In another cell having an iron anode one inch in diameter the electrical boundary of the protected cell, including all the $I_p(R_{c_f} + R_{k_c\rho})$ form of polarization the system is entitled to, was located nearly ¾-inch outside the cathode surface.

Corrosion current flow from larger areas (assumed to be all anodic) to adjoining cathodic areas of bare pipelines or other structures in soils and/or water is often controlled when a potential corresponding to E'_a is measured[7] against reference electrode located over the anode area or to a so called remote electrode. This measurement, particularly in a high resistivity soil or water, does not mean that all the localized pitting attack on the assumed gross anodic and/or cathodic areas is completely controlled.

4. The use of a highly resistive coating will decrease the importance of electrolytic resistive element $R_{k_c\rho}$ in the potential measurement. When the resistive element R_{c_f} becomes great in relation to $R_{k_c\rho}$ and the protective current I_p required is small, the structure potential observed will not vary greatly with the reference electrode location.

5. The auxiliary protective anode location has greater effect upon the protective current I_p requirements as the soil and/or water resistivity increases. See Table 2. Placing an auxiliary anode in the vicinity of the corroding anode will in effect add a part of the resistive effect of $R_{k_a\rho}$ to the resistive elements of the cathode.

6. The ratio of *protective current required* to *corrosion current* increases with increasing media resistivity. The ratio I_p/i_a in the high resistivity media of this experiment was 32 and in the low resistivity media was 3.

7. Since full protection may be attained on bare metal in a high resistivity media without an evident change in the cathodic reduction process, any break in a DC null-potential applied current curve will be difficult to correlate with the actual protective current requirements. The cathode polarization in a high resistivity media is in large part of the IR drop form and protection may be attained before there is a change in the cathode reduction process.

8. In the lower resistivity media the IR drop form of polarization is of less importance and the break in the potential-current data becomes significant.

9. The potential of mill scale is often more cathodic than copper.

10. In the higher resistivity electrolytes a protective potential E'_a observed when the current is interrupted will require more protective current than is needed since it does not include the IR drop effect from the protective current to which the system is entitled.

11. It is felt that there is much room for further study of the spatial factors entering into the determination of the proper location of the reference electrode in potential criteria measurements.

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Investigation of Synthetic Fingerprint Solutions*

By STANLEY J. EISLER* and HARRY L. FAIGEN**

Abstract

The object of this work was to investigate the validity of use of the synthetic fingerprint solution specified in present military establishment specifications. This was accomplished by comparisons with natural fingerprints and other synthetic solutions.

Two or three subjects with the most corrosive fingerprints were selected from the laboratory staff and their fingerprints were used for further comparative tests.

The specification synthetic print was found more difficult to remove than the most active natural print encountered during the tests conducted.

The specification synthetic fingerprint solution and other synthetic solutions investigated, despite moderate differences of concentration and constituency, were equally effective in evaluating fingerprint removing compounds.

On the basis of the limited evidence available, the specification synthetic fingerprint solution corresponds more closely to the concentration and pH of hand secretions normally encountered than do other synthetic solutions, which, in the main, are based on analyses of general body sweat.

Introduction

IN PREPARING material for storage, two factors are vital to successful preservation, namely:

1. The removal of corrosion-promoting dirts before the final application of rust preventives.
2. The preservation of the surfaces in unrusted condition between the cleaning operation and the rust preventive application.

Probably the most ubiquitous and troublesome of the corrosion accelerating contaminants encountered are fingerprint residues resulting from manual handling. These residues can be removed by the use of aqueous alkaline or emulsion cleaners. However, they are not removed from steel surfaces by the usual solvent or solvent vapor degreasing procedures and produce local corrosion under most subsequently applied rust preventives.

Frequently, aqueous cleaning procedures are inconvenient, undesirable or impossible to use. Rinsing or swabbing with methyl alcohol containing small percentages of water has been employed in some cases. But this procedure is subject to severe health and fire hazards and requires the application of a temporary rust preventive if the final protective material is not immediately applied.

The approach to a solution of this problem which has received the greatest industrial and ordnance attention has been the use of solvent type cleaner-preservatives such as were employed in this investigation. Besides the protective and non-corrosive qualities conventionally required from such materials, the all-important functional characteristics expected would be the ability to neutralize and remove fingerprint and other acidic or salt-type contaminants. Water displacing characteristics would also constitute a desirable property. Further, the temporary protective films deposited should be fully compatible with more permanent rust preventive materials which might subsequently be most conveniently applied without intervening cleaning.

Analyses of sweat made by various investigators and tabulated in Table 1 indicate that there is a wide variation in the composition of human perspiration collected from various individuals and from the same individual at different times. The constituents listed are apparently the only ones lending themselves to quantitative analysis.

Referring to Column 5 of Table 1, it will be noted that the analysis of Lobitz and Osterberg is the only analysis of palmar sweat found in the literature. Their determinations indicate that the sodium chloride concentration in palmar sweat is 2 to 4 times that in general body sweat. Their values for sodium chloride and urea are also much higher than the averages of the values of other investigators (see Table 2).

The complexity of the composition of sweat itself, coupled with the variations found among individuals, place of collection and time of collection makes it essential that a simplified synthetic solution be developed in order to standardize the fingerprint removal test for fingerprint removing compounds. The compositions of several of these synthetic solutions are presented in Table 2.

The problem is therefore resolved to the practical consideration of comparing the ease of removal of the synthetic print with that of typically active natural prints, using given fingerprint removing compounds. However, allowance must be made for the possibility that in any limited investigation, the maximum degree of activity of natural prints encountered may fall far short of the maximum which might occur on broader sampling.

Comparison of Synthetic vs. Natural Prints

Twenty male members of the laboratory staff were investigated to determine the corrosiveness of their fingerprints, in order to find two or three virulent printers for the subsequent tests.

The procedure used to obtain the prints was as follows:

1. The subject washed and rinsed his hands thoroughly.
2. One hand was placed in a clean surgeon's rubber glove and clenched and unclenched for 10 minutes.
3. The thumbprint was then taken by pressing the thumb with moderate pressure on a previously polished and cleaned steel test panel.
4. The printed panel was then dried in an oven at 250 degrees F for 5 minutes.

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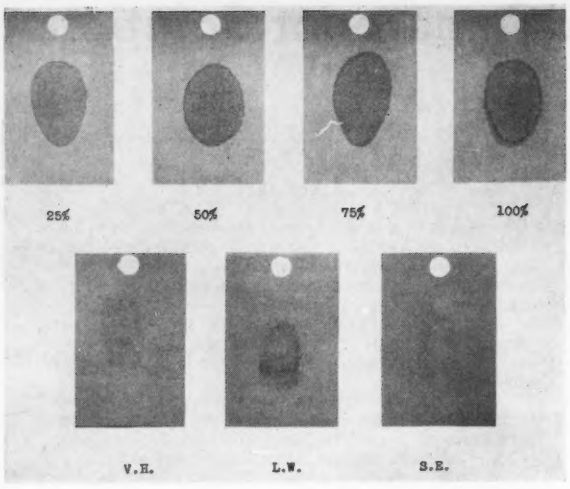

Figure 1—Comparison of various strengths of synthetic solution D with natural fingerprints. No removal treatment. Exposed 18 hours in 100 percent static humidity at 77 degrees F.

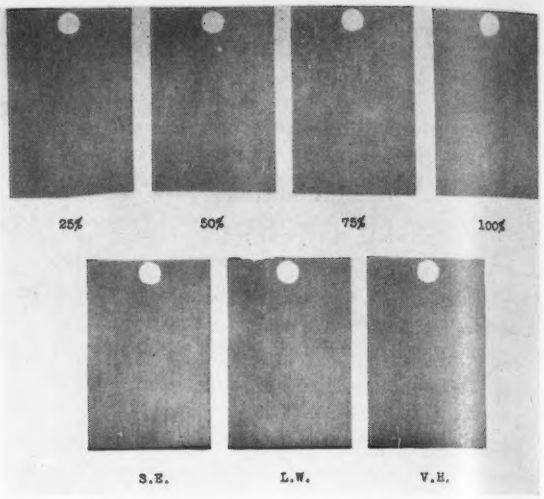

Figure 2—Comparison of various strengths of synthetic solution D with natural fingerprints. Removal in Compound I. Exposed 18 hours in 100 percent static humidity at 77 degrees F.

5. The panels were then exposed in a 100 percent static humidity at 77 degrees ± 2 degrees F for 18 hours.
6. After exposure the panels were inspected to determine the intensity of corrosion on each of the panels.

Three of the subjects were selected for further tests based on their ability to produce prints which gave the maximum intensity of corrosion.

The prints of the above-mentioned subjects were compared with various strengths of the synthetic solution prepared in accordance with Specification AXS-1719 by the following two methods:

1. Panels printed with 25, 50, 75 and 100 percent strengths of the fingerprinting solution (one drop

TABLE 1—Analyses of Human Perspiration

Data in Milligrams Per 100 Cubic Centimeters

Inorganic Constituents:	COLUMNS ARE NUMBERED TO CORRESPOND WITH FOOTNOTES																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Sodium Chloride	230	73–850	300		300-400 650-1450*		300–370	500	390			320–650						
Ammonia		13.3-41.2				4.7-8.5	5.7-7.3	7.3				4.0-21.1				6.0-42.4		
Phosphorus																	0–4.88	
Sulphur																	0–7.37	
Organic Constituents:																		
Urea		21.4-132			68–275*		41–45.8	32.5	14.3			5.0-112.5			51–240			
Lactic Acid				250–350					200	71–160								68–122
Reducing Agents Expressed as Glucose					2.86–3.08*		12.6–20.0				2.8–40.0		5.6–40.0					
Amino Acids														1.66–4.76				
Amino Acid N							5.6–6.5											
pH		4.6–5.9			5.2–6.7*	5.1–6.8	6.1–6.6	6.7–8.4										7.2-7.8‡ 4.4†

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* Palmar sweat. All other values refer to general body sweat.
‡ After careful washing.
† Without careful washing.

TABLE 2—Comparison of Analyses and Formulations

Mg/100 cc*

Constituents	ANALYSES				SYNTHETIC FORMULATIONS			
	GENERAL BODY SWEAT		PALMAR SWEAT		Spec. A&S 1719	Air Forces 14156	ALL OTHERS	
	Average	Range	Average	Range			Average	Range
NaCl	386	73-805	1050	650-1450	700	525	510	300-1000
NH_3	14.7	4.0-42.4	.....	.....	...	...	6	.....
Phosphorus	2.44	0.0-4.88	.....	.....	...	...	...	.....
Sulphur	3.69	0.0-7.37	.....	.....	...	...	...	.....
Na_2SO_4	.....	.....	.....	.....	...	...	90	.....
Na_2HPO_4	.....	.....	.....	.....	...	...	20	.....
NaH_2PO_4	.....	.....	.....	.....	...	...	100	.....
NH_4Cl	.....	.....	.....	.....	...	...	80	.....
NH_4OH	.....	.....	.....	.....	...	...	40	.....
Urea	69.5	5.0-240	171	68-275	100	75	87	50-200
Lactic Acid	174.0	71-350	.....	.....	400	300	142	100-200
Glucose	20.1	2.8-40.0	2.97	2.86-3.08	...	...	15	.....
Amino Acid	3.21	1.66-4.76	.....	.....	...	...	...	.....
Amino Acid N	5.75	5.0-6.5	.....	.....	...	...	...	.....
Olein	.....	.....	.....	.....	...	...	200	.....
Stearin	.....	.....	.....	.....	...	...	200	.....
Butyric Acid	.....	.....	.....	.....	...	...	37	25-50
Acetic Acid	.....	.....	.....	.....	...	...	100	.....
1 Percent Acetic Acid Solution	.....	.....	.....	.....	...	...	35cc	20-50
Distilled H_2O	.....	.....	.....	.....	125cc	125cc	To 1	.....
Methyl Alcohol	.....	.....	.....	.....	To 1 Liter	To 1 Liter	Liter	.....
pH	6.33	4.4-8.4	5.95	5.2-6.7	3.45	...	5.6	4.0-7.5

* Unless otherwise indicated

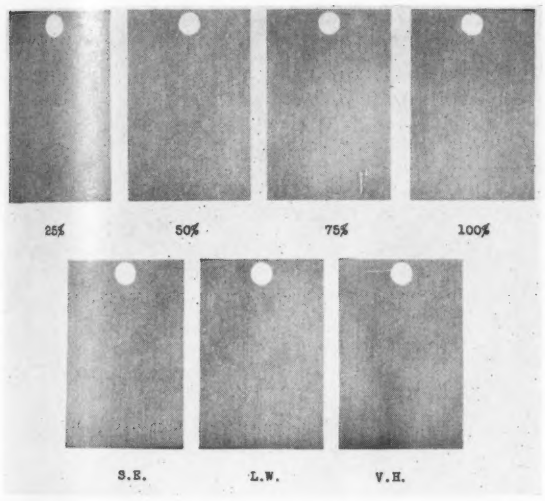

Figure 3—Comparison of various strengths of synthetic solution D with natural fingerprints. Removal in Compound II. Exposed 18 hours in 100 percent static humidity at 77 degrees F.

per panel) and panels printed by the subjects in accordance with the preceding paragraph above were prepared. These panels were then exposed without any further treatment in a 100 percent static humidity at 77 degrees ± 2 degrees F for 18 hours. The intensity of rusting, as distinguished from the total amount or area of rusting, was then compared. The results pictured in Figure 1 indicate that on the basis of the maximum intensity or depth of rusting anywhere in the fingerprint area, the print of L. W. was approximately equivalent to that of the 50 percent strength of the AXS-1719 solution. This comparison, which is not too evident from the photograph was at best a rough approximation.

2. Five panels were printed by each subject and with each of the four strengths of synthetic solution as in 1 above. One of each group of five panels was agitated for two minutes in one of five commercial

TABLE 3—Synthetic Perspiration Formulations

Grams Per Liter*

Inorganic Constituents	COLUMNS ARE NUMBERED TO CORRESPOND WITH FOOTNOTES							
	1	1	2	3	4 (acid)	4 (alk.)	5	6
NaCl	8	10	3	2.5	3.5	3.5	7	5.25
Na_2SO_4	.....	.....	0.1	.....	.....	.....	.....	.....
NH_3	.....	.....	.....	0.06	.....	.....	.....	.....
Na_2HPO_4	.....	.....	.....	.....	0.2	0.2	.....	.....
NaH_2PO_4	.....	1	.....	.....	.....	.....	.....	.....
NH_4Cl	.....	.....	.....	.....	.....	0.8	.....	.....
NH_4OH	.....	.....	.....	.....	.....	0.4	.....	.....
Organic Constituents								
Urea	.....	.....	2	0.5	0.5	0.5	1	0.75
Lactic Acid	.....	1	2	1.25	.....	.....	4	3
Olein	.....	.....	2	.....	.....	.....	.....	.....
Stearin	.....	.....	2	.....	.....	.....	.....	.....
Butyric Acid	.25	.....	.....	.5	.....	.....	.....	.....
Glucose	.....	.....	.....	.....	0.15	0.15	.....	.....
Acetic Acid	1	.....	.....	.....	.....	.....	.....	.....
1 Percent Acetic Acid Solution	.....	.....	.....	.....	20 cc	50 cc	.....	.....
Solvents								
Distilled H_2O	To 1 Liter	To 1 Liter	To 1 Liter	To 1 Liter	To 1 Liter	To 1 Liter	125cc	125cc
Methyl Alcohol	.....	.....	.....	.....	.....	.....	To 1 Liter	To 1 Liter
pH	.....	.....	.....	4 or 6	Acetic Acid to give 5.0	Acetic Acid to give 7.5	.....	.....

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* Unless otherwise indicated.

TABLE 4

Comparison Tests of Synthetic vs. Natural Fingerprints

	PERCENT EFFICIENCY OF REMOVAL IN COMPOUNDS*				
	I	II	III	IV	V
25 Percent Sol'n. D.	100	100	100	100	30
50 Percent Sol'n. D.	100	100	99	90-93	<10
75 Percent Sol'n. D.	100	100	85-87	85	<10
100 Percent Sol'n. D.	100	100	70-75	60	<10
S. E.	100	100	100	100	<10
L. W.	100	100	100	100	<10
V. H.	100	100	100	100	<10

* Estimated Visually.

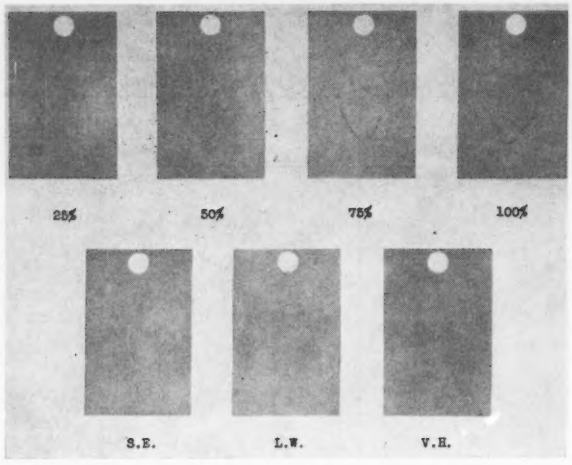

Figure 4—Comparison of various strengths of synthetic solution D with natural fingerprints. Removal in Compound III. Exposed 18 hours in 100 percent static humidity at 77 degrees F.

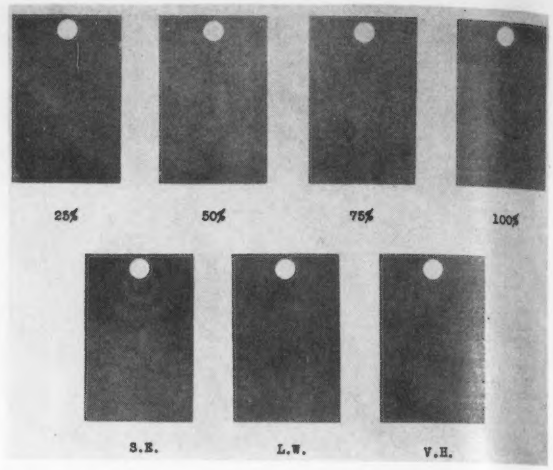

Figure 5—Comparison of various strengths of synthetic solution D with natural fingerprints. Removal in Compound IV. Exposed 18 hours in 100 percent static humidity at 77 degrees F.

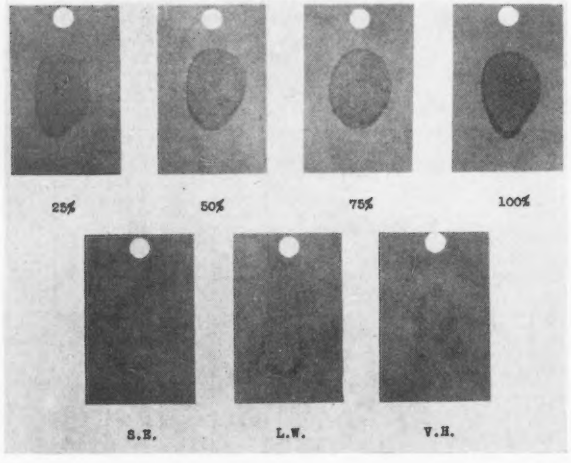

Figure 6—Comparison of various strengths of synthetic solution D with natural fingerprints. Removal in Compound V. Exposed 18 hours in 100 percent static humidity at 77 degrees F.

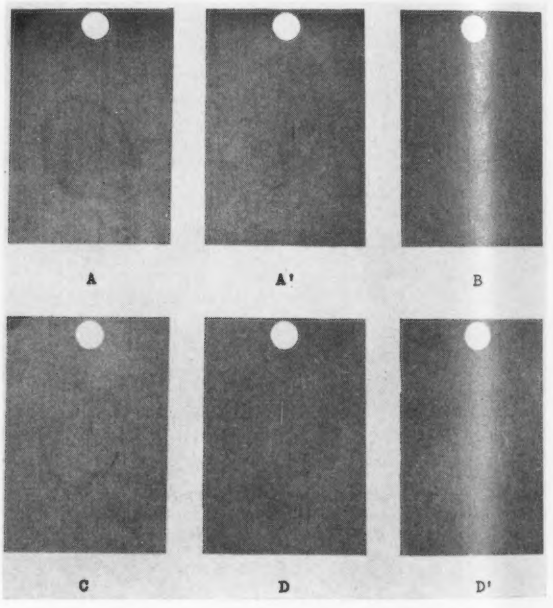

Figure 7—Comparison of various synthetic fingerprint solutions by removal in Compound I. Exposed 18 hours in 100 percent static humidity at 77 degrees F.

TABLE 5

Synthetic F. P. Solutions Used for Comparison Tests

	COLUMNS ARE NUMBERED TO CORRESPOND WITH FOOTNOTES			
	A[1]	B[2]	C[2]	D[3]
NaCl	10	3.5	3.5	7
NaH_2PO_4	1	...	...	.....
Na_2HPO_4	...	.2	.2	.....
NH_4Cl	...	...	.8	.....
NH_4OH	...	...	.4	.....
Urea	...	.5	.5	1
Lactic Acid	1	...	...	4
Glucose	...	.15	.15	.....
1 Percent Acetic Acid Solution	...	20cc	50cc	.....
H_2O	125cc	105cc	75cc	125cc
Methyl Alcohol	To 1 Liter	To 1 Liter	To 1 Liter	To 1 Liter
pH	4.6	5.7	7.4	3.45

1. H. Bennett. The Chemical Formulary. Chem. Pub. Co., **I**, 352, **V**, 567.
2. F. Jordinson. The Action of Sweat on Dyed Cotton Goods. *Indian Textile J.*, **51**, 247-9 (1941).
3. C. E. Waring, Frigidaire Corp. Used in Spec. AXS-1719.

• Unless otherwise indicated.

fingerprint remover compounds, (these materials are generally solubilized oil and water mixtures) designated Compounds I, II, III, IV and V, rinsed in Pentasol (mixed isomers of amyl alcohol) and petroleum solvent and then exposed under the same conditions as in 1 above for 18 hours. The panels were then compared on the basis of effectiveness of removal by each of the five compounds. The results are given in Table 4 and are pictured in Figures 2 to 6 inclusive. While both natural prints and all dilutions of the synthetic prints were removed completely by compounds I and II the difference in ease of removal of the two types of prints becomes evident when

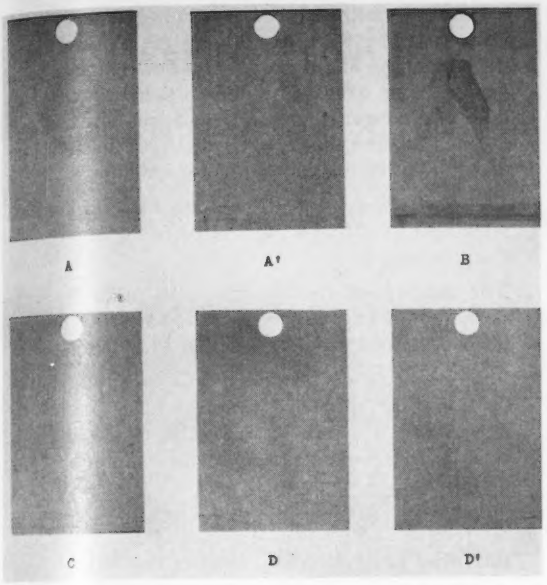

Figure 8—Comparison of various synthetic fingerprint solutions by removal in Compound II. Exposed 18 hours in 100 percent static humidity at 77 degrees F.

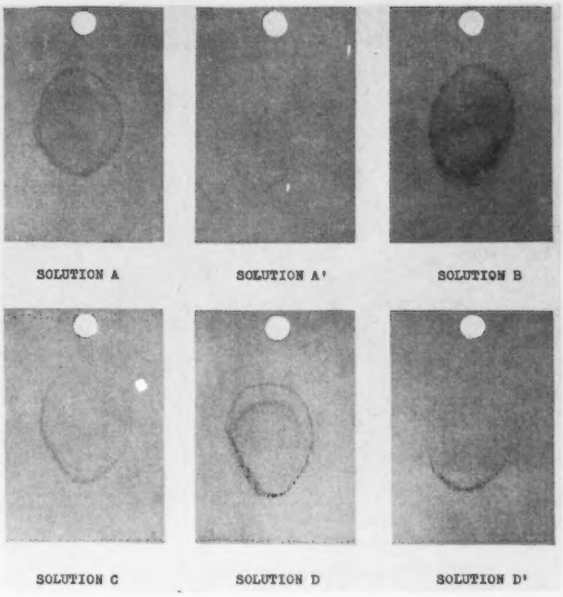

Figure 9—Comparison of various synthetic fingerprint solutions by removal in Compound III. Exposed 18 hours in 100 percent static humidity at 77 degrees F.

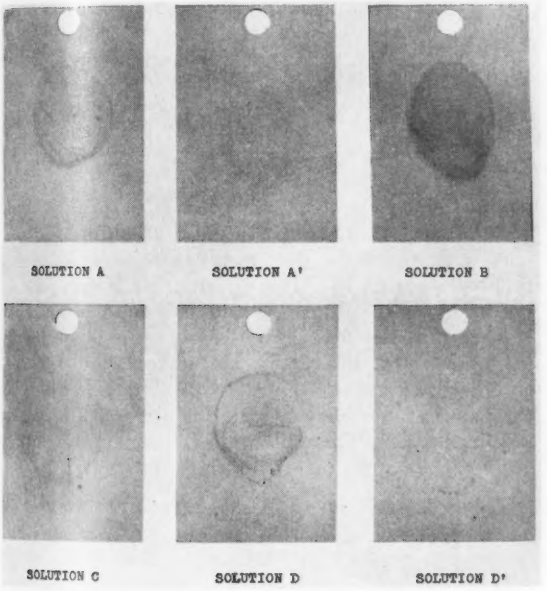

Figure 10—Comparison of various synthetic fingerprint solutions by removal in Compound IV. Exposed 18 hours in 100 percent static humidity at 77 degrees F.

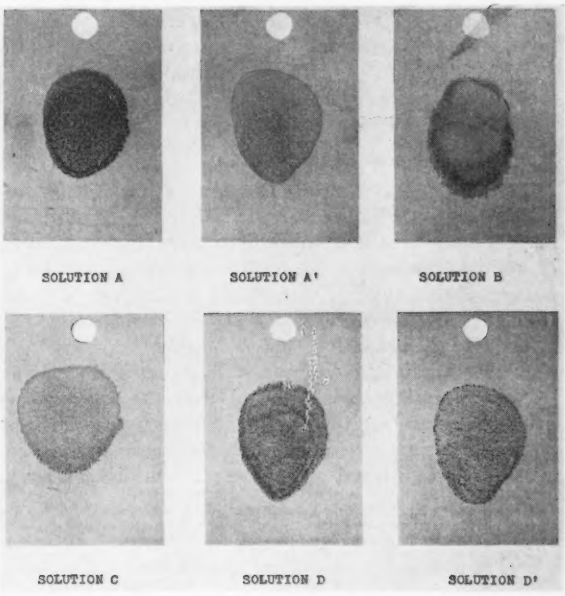

Figure 11—Comparison of various synthetic fingerprint solutions by removal in Compound V. Exposed 18 hours in 100 percent static humidity at 77 degrees F.

using compounds of limited effectiveness (III and IV) and of little effectiveness (V). This is shown vividly in Figures 4 and 5 where 100 percent effectiveness was attained in removing all natural prints but not in synthetic prints until there was a dilution of over 50 percent in the strength of the synthetic solution used. Figure 6 is of particular interest in demonstrating that a commercial material widely sold as a "Finger-Print Remover" has little or no removal effect on both synthetic and natural prints.

Comparison of Various Synthetic Solutions

The comparison of the fingerprint solution specified by Specification AXS-1719 against other synthetic solutions was made by the latter method described in the preceding paragraph. The synthetic solutions used were prepared in accordance with the formulae given in the literature and also on the basis of approximately equivalent contents of sodium chloride, which is considered the most active corrosion

constituent of sweat. The formulae are given in Table 5 and the various solutions are identified as follows:

A — from Bennett[1]
A′ — 35% of A + 65% methyl alcohol
B — acid formulation from Jordinson[2]
C — alkaline formulation from Jordinson[2]
D — from Specification AXS-1719
D′ — 50% of D + 50% methyl alcohol

The above solutions were all standardized so as to contain 125 cc of water to dissolve the solids and then methyl alcohol was added to one liter. This was done to facilitate drying after printing and thus prevent rusting by the water in the solution. The results are given in Table 6 and pictured in Figures 7 to 11 inclusive. It will be noted that all synthetic prints were removed by Compounds I and II,* with varying degrees of efficiency by Compounds III and IV and not at all by Compound V. The differences among various synthetic solutions is best shown in Figure 11 where there has been practically no removal. A comparison of the intensity of the rusting reveals the following:

1. Solution A (greatest rust intensity)
2. Solution D
3. Solutions D′, A′ and B (equal)
4. Solutions C

This sequence is what might be expected as the solution with the highest salt content was the most corrosive and the corrosiveness decreased as did the salt content. Solution C, although containing the same percentage of salt as solutions A′, B and D′ was less corrosive due to its alkalinity, while the other are acidic (see Table 5).

Discussion

The results comparing the synthetic solution and natural prints, obtained by the two methods of attack, i.e., the non-treatment and the removal methods, were in good agreement considering the semi-quantitative nature of this type of test. A certain degree of variation is inevitable in any test which is dependent upon visual evaluation which in turn depends upon the individual's idiosyncracies of perception.

The overall results indicate that the most active print found among the subjects tested was equivalent to a synthetic print made with the solution specified in AXS-1719, diluted to between 25 and 50 percent of full strength with methyl alcohol. The discrepancy which exists between the above results and the results which might be expected from the relative salt concentrations (the analysis of palmar sweat indicates a salt concentration one and one-half times that contained in the full strength synthetic solution) may be explained by the following reasons:

1. The particular subjects used may or may not have produced as active a natural print as may be found elsewhere.
2. The acidity of the synthetic solution is greater than any of the values found in the literature for human perspiration (see Table 3).
3. Since the rusting produced on a steel panel is proportional to the total amount of corrosive salts deposited on a limited area, the total quantity as well as the concentration of the solution or sweat deposited is of importance. The weight of five fingerprints printed upon a glass panel could not be determined by use of an analytical balance. On the other hand, it is known that the salt content of one drop of the synthetic solution, ordinarily applied as a synthetic print, equals 0.6 mg. This indicates that a larger quantity of salt was deposited by the larger volume of synthetic solution although its concentration may have been lower than that of natural sweat.

Substantiation of the statement that the amount of rusting is proportional to the amount of corrosive salts deposited may be found in Figure 1 where there is a regular gradation in intensity from the 25 percent print up through the 50 percent and 75 percent prints to the 100 percent print. This fact is more obvious when viewing the panels as part of the effect of the rust buildup is lost in photographing.

A comparison of the percentage effectiveness of removal ratings in Table 6 with the corresponding photographs in Figures 9 and 10 would lead one to believe that the percentages assigned were too high in some cases, indicating better removal than pictured. However, this is due to a stain remaining on the panel after removal, which is not rust but photographs as such. This condition is particularly noticeable on the panels printed with Solution B.

* Prints made with Solutions A, B and C left a whitish residue on the panel after the removal treatment which has the appearance of rust in Figures 7 and 8. The same is true of the panel printed with Solution A′, pictured in Figure 7. No rusting occurred on these panels. The nature of the residues is not definitely known but is believed to be largely the sodium hydrogen phosphate constituent.

TABLE 6

Comparison Tests of Various Synthetic Solutions

Fingerprinting Solution	PERCENT EFFECTIVENESS OF REMOVAL IN COMPOUND*				
	I	II	III	IV	V
A	100	97	90–95	90–95	<10
A′	100	100	98–100	98–100	<10
B	100	100	85–90	90–93	<10
C	100	100	90–96	95–97	<10
D	100	100	75–80	85	<10
D′	100	100	85–95	95–100	<10

* Estimated Visually.

Summary

Based on the results presented the following general conclusions may be made:

1. All synthetic solutions produced similar prints which were removed in analogous degree by the various fingerprints removing compounds, although the composition of the various solutions varied moderately with respect to type and number of constituents. This would seem to indicate that there is no need for a complex formulation although it is believed that the addition of a buffering constituent to the present solution would be advantageous if it is desired to reduce the present high acidity.
2. The use of the synthetic solution as a basis for evaluation of fingerprint removing compounds in the past has produced a large accumulation of data. The variations in behavior with difference in composition, indicated above, are not sufficiently marked to warrant a change with consequent repetition of large bodies of experimental work.

The authors express their appreciation to their co-workers at the Rock Island Arsenal Laboratory for assistance and to the Ordnance Corps, Research and Development Division of the Department of the Army and the supervisory staff of the laboratory for permission to publish the information in this paper.

References

1. H. Bennett. The Chemical Formulary. *Chem. Publ. Co.*, **I**, 352, **V**, 567.
2. F. Jordinson. The Action of Sweat on Dyed Cotton Goods. *Indian Textile J.*, **51**, 247-9 (1941).

Testing Tank Car Linings*

By J. ROBERT SPRAUL

Figure 1—Apparatus for Testing coatings.

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Abstract

The corrosion problems associated with tank car shipments are different than those encountered with stationary tank storage. Additional corrosive conditions are introduced because of the frequent loading and unloading of the car. Another factor is that the unloading of cars often is not complete and when it is not on the return trip serious corrosion can occur.

Conditions for the preferred use of protective coatings on the interior of the tank car are discussed along with life requirements. Corrosive factors such as dilution, aeration, liquid and vapor phase contact, presence of moisture, separation of phases and heat are discussed.

Long term tests would give the best estimate of the expected coating life, but frequently time requirements necessitate the use of short term accelerated studies. Various testing methods are discussed and an evaluation of their usefulness is given. In particular, a testing method incorporating partial immersion of a coated panel, aeration, humidity and heat is described and results given. Some data from actual tank car applications are presented.

AT THE CLOSE of World War I tank cars were hauling 20 to 30 different commodities, most of which were petroleum raw materials or products. At present there are approximately 150,000 tank cars operating in the United States of which 141,000 are privately owned and they haul approximately 600 different commodities. Petroleum still is the major product handled, using 95,000 of the privately owned cars. Of the remaining cars, 27,000 operate in chemical service and 19,000 in miscellaneous service.[1]

The increase in the number of commodities hauled has been due principally to the growth and diversification of the chemical industry and the increased use of the by-products of the meat packing and paper industries. The increase in the variety of ladings handled in tank cars has led to the creation of many corrosion problems. The most common solution has been protective coatings on interiors.

There are 29 different types of tank cars specified by the Interstate Commerce Commission[2] and a summary of the various cars has been published.[3] The Association of American Railroads has written additional specifications which must be met before a tank car will be accepted for interchange. The above requirements principally concern constructional details, plate thicknesses and physical test procedures. The only interior coating specified is for the ICC103B type of car where a rubber lining is called for. These cars commonly are used for hydrochloric and phosphoric acid service. It should be pointed out that corrosion damage from the commodity is the responsibility of the shipper in almost all cases. This results from the fact that the great majority of tank cars is owned by shippers or tank car leasing companies. Therefore, it generally is up to the shipper to specify the type of lining and its method of application. The service and maintenance of the protective coating is the responsibility of the lessor.

Corrosive Conditions Encountered In Tank Car Shipments

The writer has learned one important fact from experience with tank car corrosion problems. A solution applicable to corrosive conditions associated with stationary storage frequently is not satisfactory for a similar problem involving tank cars. The summary of conditions given below will point out the reasons for this statement. Any tests or series of tests which attempt to duplicate field conditions and evaluate protective coatings must consider the following conditions.

During the outbound trip the lining must resist the direct chemical action of the commodity. Since cars are never fully loaded because of the need for some expansion, the action of the vapor and the liquid level also must be considered. Temperature factors are present with some ladings which may be

★A paper presented at the Tenth Annual Conference, National Association of Corrosion Engineers, Kansas City, Mo., March 15-19, 1954.

loaded at elevated temperatures or require heating by coils to unload. In the latter case the effect of temperature on corrosion usually is concentrated on the coils themselves or at the bottom of the car and around the outlet nozzle. The presence of dispersed or emulsified impurities may lead to corrosion. The prime example of this is the settling out of water from organic compounds. This aqueous phase often contains dissolved chemicals which accelerate attack on the lining. The method of treatment or purification of the commodity should be considered. Sulfuric acid often is used to treat materials and sufficient acid may remain in the chemical to eventually settle out and cause corrosion around the outlet nozzle.

The method of manufacture of the chemical may introduce corrosion problems. Rubber linings are specified for cars handling hydrochloric acid and satisfactory service is obtained when the acid is prepared by the usual means. Because hydrochloric acid manufactured as a by-product of organic reactions may contain sufficient organic impurities to attack the rubber special rubber formulations are required.

There is little question but that the most severe corrosion conditions are prevalent during the return trip and that at least a majority of corrosion failures occur because of these conditions. This situation arises because cars frequently are not completely unloaded and often quantities from one to 50 gallons of the commodity may remain in the tank. The remaining lading splashes around and thereby becomes well aerated, introducing this additional corrosive action. In the unloading operation, air pressure may be used, or the dome cover may be opened introducing air into the tank along with associated humidity. The water vapor has an excellent opportunity to hydrolyze some ladings forming more corrosive products. This is particularly a danger with halogenated materials. Outside temperature changes may be sufficient to cause condensation of water which could dilute the commodity and lead to an entirely different corroding medium.

As examples of some of the causes of tank car corrosion other than direct attack of the commodity itself, certain particular ladings are mentioned.

Benzol-Corrosion of the coils and bottom sheets occurs due to the settling out of moisture. Some manufacturers do a good job of removing the moisture from their product and seldom, if ever, have coil corrosion. Others, who do not have a good dehydrating step or use the tank car as a settling tank, have to replace coils every three to ten years. Corrosion of the bottom sheet also occurs.

Carbon Disulfide—This commodity gives a pattern similar to benzol in that the corrosion occurs around the bottom sheet due to water settling. Although the literature indicates that the hydrolysis of carbon disulfide is negligible at ordinary conditions, analysis of rust samples from these cars has shown the presence of iron sulfide compounds.

Tall Oil—This commodity is not particularly corrosive at room temperature, but the introduction of heat through the coils accelerates corrosion around the outlet nozzle, bottom sheet and the coils themselves. Similar damage has been noted as a result of handling other paper mill products.

Carbon Tetrachloride—Corrosion has been experienced around the dome area and top sheet of the cars due to hydrolysis of the carbon tetrachloride to produce hydrochloric acid.

Liquefied Petroleum Gases—The law requires that certain mercaptans be added to these gases and these mercaptans have a slightly higher density than the liquefied gas. Corrosion due to settling of the mercaptans has been experienced but this is due primarily to poor operating practice and improper purging.

Molten Sulfur—Corrosion by this material, even at the temerature of shipment is not excessive as indicated by corrosion tests at continuing elevated temperatures. However, if the specimen is periodically cooled and heated, as would be the case in a car, the rate increases rapidly due to the fact that the expansion and contraction of the base metal breaks the protective film of iron sulfide compounds.

Sulfuric Acid (66°Be)—At this concentration the acid is not corrosive to steel, but upon unloading moist air is introduced into the car. This moisture dilutes the acid on the roof of the tank and forms a corrosive concentration. All sulfuric acid cars have grooves or "riflings" from the top sheet down the side of the car.

Tanks for railroad tank cars are built of flange-quality boiler plate and must have the following analysis according to AAR Specification M-116-52.

	Ladle Analysis	Check Analysis
Phosphorus, max., percent:		
Open hearth or electric furnace:		
Acid	0.060	0.075
Basic	0.040	0.050
Sulfur, max., percent:		
Open hearth or electric furnace:	0.050	0.063
Copper, when specified, min., percent	0.20	0.18

In all cases where linings are being considered, corrosion tests including at least partial and total immersion experiments should be conducted on specimens of uncoated flange-quality boiler plate. Depending upon shipping conditions other test methods described below may be included. General American Tansportation Corporation experience indicates that a coating should be used if the corrosion rate from either partial or total immersion is greater than 0.005-0.007 inch penetration per year, depending upon the thickness of the plate required. Further it is the author's opinion that if the corrosion rate on boiler plate is greater than 0.05 to 0.1 inch penetration per year, a protective coating should not be considered, but the tank should be made of alloy or clad construction. The reasoning behind this last criterion is that there is too great a chance for at least partial lining failure and that the corrosion rate on steel is high enough to be a safety hazard.

The design life for an interior lining should be at least three years. This is based on the fact that, on the average, a tank car is returned to the shops for inspection and repair every 36 months. The car can be given minor and running repairs by the railroads and at many locations. Qualified personnel for inspecting and evaluating the condition of a lining usually are available at tank car repair shops. This is a good time to touch up or replace a lining while the car is out of service. Many car shops have facilities for lining tanks or independent operators are available in the area. Bringing the lining back to proper operating condition at this time saves removing the car from service later. For highly corrosive commodities or those where iron pick-up is critical, inspection by the shipper before each load is recommended.

Coating Testing Methods

Methods described in this section principally are of the accelerated or short term type. It should be mentioned that there really is no substitute for a long term evaluation of a protective coating. By long term is meant one, two or three years. Tank cars are not available for inspection as are stationary storage tanks in a plant and therefore the reliability of the testing methods should be as good as possible.

The test method used in General American's Laboratory involves a cyclic procedure including aeration, slight heating and quiescence. The tests are conducted in large-mouth bottles of the screw cap type and coated panels or torpedoes (usually supplied by the paint manufacturer) are partially immersed in the commodity. The bottles are 8½ inches high and 5 inches in diameter. Generally 500 ml of test liquid are used and this will cover one-half of the common 2 by 5 inch corrosion panel. In a 10,000 gallon tank car there are approximately 1000 square feet of interior surface which must be coated, giving a ratio of 10 gallons of commodity per square foot. The test being described does not meet this ratio, but is instead about two to one, based on the portion of the panel immersed. A view of the typical test setup is shown in Figure 1.

The test cycle commonly used is 15 minutes of aeration, 15 minutes of infra-red light and heat and 15 minutes of quiescence. The various operations are controlled by automatic timers and the test period is three weeks. Purpose of the infra-red light is not to apply radiation to the panel but to expose the panel to a temperature of 150-165 degrees F. It has been found that the tank can attain such temperatures in some parts of the country during the hot season so the interior coating must be able to withstand this temperature. With certain commodities, depending upon the physical and chemical properties of the material, either the aeration or heating cycle or both are eliminated to prevent excessive evaporation, polymerization or chemical reaction of the commodity.

The above testing procedure is used in the GATX laboratory to evaluate new coating systems or protective lining products. The company prefers to receive both test panels and liquid samples for laboratory evaluation. Rectangular steel panels are preferred to torpedos because panels permit evaluation of edge effects. On panels tested the paint is required to protect edges as well as faces. Inside the tank cars there definitely are edges and the coating thickness must be sufficient to protect them. The GATX laboratory has not used a more complex testing panel, such as the Kenneth Tator Associates* panel. This panel certainly should increase the reliability of tank car lining corrosion tests, but GATX does not feel that the extra cost of preparation and application is justified.

Before starting the corrosion test the paint thickness is measured by a General Electric Type B thickness gauge. Except for a few cases where the coating is being used to prevent iron contamination, the thickness should be five mils or more. If the paint thickness is less than this, porosity is checked with a spark tester.

Each new coating system is subjected to the standard three week corrosion test in six classifying commodities, as follows:

20% acetic acid—an organic acid

14% hydrochloric acid—a reducing acid

20% sulfuric acid plus 5% sodium dichromate—an oxidizing acid

20% sodium hydroxide—a basic solution

Toluene—an aromatic

Kerosene—an aliphatic fraction

Performance of the coating in these test solutions can be used for analogous comparisons to determine types of compounds which will resist and for which it might be considered a suitable tank car lining. This series of classifying tests is admittedly weak in organics and does not include such common materials as alcohols, ketones, amines and oils.

Over a period of seven years a number of coating systems have been tested in these classifying commodities. A summary of the results is given in Table 1. Not all of these coatings met the requirements of five mils thickness but in all cases panels submitted by the manufacturer or prepared according to their directions were used. It should be mentioned also that tests were made in corrosive agents even in some cases when suppliers did not particularly recommend their products. With all corrosive media, the total tests include duplicates with particular sys-

* See CORROSION, March, 1952, front cover illustration.

TABLE 1
Summation of Test Results of Coating Systems Versus Six Classifying Commodities

CORROSIVE MEDIA	No. of Systems Tested	No. of Failures	Percent Failures
20 percent sulfuric acid plus 5 percent sodium dichromate	449	404	90
14 percent hydrochloric acid	434	370	85.4
20 percent acetic acid	397	318	80.2
20 percent sodium hydroxide	414	241	58.3
Toluene	351	247	70.4
Kerosene	321	111	34.6

tems or with slight adaptations. From these classifying tests and studies of other commodities shipped in tank cars, experience has been obtained which permits a reasonably good preliminary selection of coatings which may be satisfactory with a new commodity. The protective systems thus selected then are tested against the new commodity by the procedure described above to select the most promising ones for field evaluation. Some typical examples of linings which have been used in actual practice are given in Table 2.

At the March, 1952 meeting of the National Association of Corrosion Engineers, Technical Practices Subcommittee TP-15A (now T-3E-1) Corrosion Control of Railroad Tank Cars was organized. Most committee members are from chemical companies that use tank cars for the shipment of their products. In general, they have a much longer time to study the corrosion problems of shipment, having been familiar with the product during processing. These corrosion engineers frequently make total immersion tests of coated panels with the commodity changed periodically and held at elevated temperatures if the practice is to load it hot. Coated container tests are valuable with chemicals which develop pressure. This type of test duplicates actual shipping conditions better than any accelerated test and should be particularly reliable if periodic cycles with very low fillages and air is introduced into the vapor space.

In the General American laboratory an alternate immersion test to evaluate protective coatings is used from time to time. A complete cycle of immersion and removal every 20 minutes is used. The investigation of this testing technique has been limited to relatively few commodities and the testing time to three weeks. The alternate immersion test originally was investigated because it was felt that the test procedure would duplicate the actual operation conditions of frequent loading and unloading. Limited experience has shown this test to be less severe as an accelerated corrosion test than the partial immersion technique with aeration described above. In several cases fans were employed to accelerate evaporation but this did not hasten failure sufficiently to make it show up in a three-week test.

Another method of value in detecting corrosive conditions in the vapor state and the tendency toward hydrolysis is what is termed an "inverted fish bowl" test. Three ordinary glass fish bowls, 8 by 8 by 11½ inches are used in the inverted position to give a closed air-tight space. Under one bowl a panel is exposed to the vapors of the commodity, which is placed in an open evaporating dish. Under another bowl dishes of the commodity and water are exposed with the panel. In the third, water only is present as a blank. Because this is not an accelerated test the time should be extended as long as possible.

TABLE 2

Typical Examples of Linings Which Have Been Used for Tank Car Shipment

COMMODITY	Type of Lining	Remarks
Muriatic Acid	Rubber-sheet or latex.	
Caustic Soda (73%)	Rubber latex coatings.	
Caustic Soda (50%)	Rubber latex and vinyls.	
Wine	Vinyls.	
Acetaldehyde	Phenolics.	
Glucose syrups	Aluminum paints.	To prevent iron pick-up.
Sugar Syrup	Vinyls.	
Glycerol	Aluminum or zinc metal spray.	To prevent iron pick-up.
Acetone	Phenloics.	To prevent iron pick-up.
Corn Oil	Aluminum paint.	
Alcohol	Tin metal spray and vinyls.	
Phosphoric Acid	Vinyls.	
Formaldehyde	Phenolics and rubber.	
Carbon Tetrachloride	Phenolics.	

Evaluation of Test Panel Resistance

For testing of coatings for tank car use the author much prefers the use of panels over torpedoes. Whichever type is used, it is critically important to know the method of surface preparation, the number of coats used and the final dry coating thickness. These facts should be reported as part of the test results.

Physical configuration of test specimen is an important fact which should be known to the person finally choosing the coating for field application. Not only should the dimensions, such as length and width be given, but the radius of all curved edges should be recorded. Thus a coating which has given satisfactory results on a panel with relatively sharp curvatures would be preferred to a coating which has been tested on a torpedo with larger curvatures. A statement should accompany every corrosion test report specifying the proper radius of curvature to which all sharp edges in the tank car should be ground to coincide with the physical configuration of test specimens used. A prime reason for failure of interior linings in tank cars has been the lack of agreement and understanding among users and applicators about what should and should not be done concerning the surface preparation of a car for lining application.

Resistance of the test specimen to the commodity should be periodically evaluated by visual examination and other tests if necessary. In order to be considered further, the coating should remain firm and not exhibit blisters, peeling or checking characteristics. It should be offering perfect protection to all surfaces and edges of the test specimen. Periodic microscopic examination of the panel will assist in evaluating the coating's protective characteristics. At the end of the test period, the use of a porosity procedure such as the ferroxyl test[4] is valuable.

During the course of the corrosion test, the commodity itself should be watched carefully for signs of change. Discoloration of the test liquid may be the first or the only sign of lining failure and this discoloration may result from iron contamination due to the porosity of the coating or due to the leaching of a component from the lining.

Corrosion of Coils

Tank cars frequently are equipped with rows of internal coils for purposes of remelting or liquefying the commodity when the car arrives at its destination for unloading. These coils are made of 2-inch lap welded, seamless or electric resistance welded steel or wrought iron pipe. Steam at pressures up to

200 psig is used for heat. Although the steam is applied only at the time of unloading and not throughout the trip, the introduction of this temperature effect causes some serious corrosion problems. With many commodities the corrosion rate rises rapidly above 200 degrees F and the coil temperatures during unloading frequently are above 350 degrees F.

The use of protective coatings on these coils has been limited and usually thicker coils or alloy materials have been preferred. Corrosive conditions are severe in that coil coatings must withstand corrosive action of the commodity at an elevated temperature and must maintain a continuous protective film despite considerable expansion and contraction of the basis metal. A further difficulty is introduced by the fact that the coils must be coated after they are in place. Because they are commonly located about four inches from the bottom sheet of the car, application of a coating is difficult and expensive. Temperature limitations eliminate vinyls and rubber base coatings and many phenolics are too brittle for this application. However, in the last few years, with the improvements in phenolic coatings, and the introduction of newer types of temperature resistant coatings such as zinc base materials and alkyd-silicone formulations there has been a renewed interest in the possibility of coating tank car coils.

GATX laboratories have undertaken some investigations to determine which linings show sufficient promise to be considered for coil application. For testing purposes a U-bend made of coil material is prepared and coated with the protective lining. Initial work has been limited to tall oil which has caused some serious coil corrosion and which is easily obtainable and easy to handle. Coatings under consideration are applied first to a small test panel and subjected to the tall oil at 350 degrees F for three weeks. If the coating withstands this test it is then subjected to the regular test on a coil U-bend. The present test procedure consists of immersing the coil bend in a five gallon container of the commodity. Steam at 125 psig is introduced into the coil each morning for 30 minutes and then turned off, and the tall oil then is allowed to cool until the next morning. Another variation in the procedure is to raise the coil out of the commodity after the steam is turned off and allow it to cool in air. This latter procedure more nearly duplicates actual operating conditions. Because this work has just been started it is too early to report trends regarding testing methods or possible satisfactory coatings.

Conclusions

In considering the possible use of a protective-coating for the interior of a tank car, the first step should be a careful study of the physical and chemical properties of the commodity to be carried in the car including the steps in its manufacture or purification which might introduce corrosive impurities. The testing methods then selected should contain variations which would submit the coating to prevalent corrosive conditions such as aeration, moisture, dilution, phase settling or temperature.

References

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3. J. R. Spraul. Transportation by Railroad. *Chemical and Eng. News*, **29**, 2029 (1951) May 21.
4. H. H. Uhlig. Corrosion Handbook. P 1033. John Wiley and Sons, New York (1948).

DISCUSSION

Question by D. Roger Loper, San Francisco:
Do you use high strength low alloy steels for tank cars and if so do you find any difference between performance of coatings on such steels and on plain carbon steels?

Reply by J. Robert Spraul:
To the best of my knowledge high strength low alloy steels have never been used as a construction material for tank car tanks.

Question by Otto H. Fenner, Monsanto Chemical Co., St. Louis:
What is the cleaning method employed by General American Transportation Corporation to remove the sludges that accumulate beneath the coils in tank cars? Do they circulate a solution of a detergent, introducing it into the tank car under high pressure through a spray nozzle, or do they have men enter the tank car and actually dig out the materials?

Reply by Robert H. Spraul:
Our practice with such cleaning problems is to thoroughly steam the car and subsequently flush out loose material with water. If this does not do a thorough cleaning job, then the remaining material is removed by hand.

Survey of Corrosion Control In California Pumping Wells*

By FRANK E. DAVIE and PRESTON W. HILL

Introduction

IN ORDER to evaluate results of an active program of corrosion control for pumping wells in California, the membership of the National Association of Corrosion Engineers' TP-1A Committee* cooperated in supplying data on wells that have been under control. An analysis of these data is the subject of this paper.

A questionnaire was prepared on hand-sort punch cards and distributed to committee members. The data requested included well location, well production, inhibitor treatment and well pulling and material replacement statistics for a period before and after treatment.

Figure 1 shows a reproduction of the questionnaire on one of the cards. To illustrate how it was used, it has been filled out with the calculated data for the average of all wells in the survey and punched accordingly. In order to obtain representative sampling, the survey was limited to those wells for which complete data were available for at least 12 months before and 12 months after treatment. A total of 348 data cards was received from 14 companies covering 17 fields. Although there are perhaps 3000 wells being treated currently in California, it is believed that the data are reasonably representative.

Results of Survey

To illustrate the size, depth and percentage of water in the production, or "cut," of the wells in the survey, the cards were sorted for those factors. The percentage distribution of wells as to size in terms of gross barrels produced per day is shown on the left in Figure 2, while the percentage distribution by pump depth is given on the right. The distribution of wells by percentage cut is shown in Figure 3.

The general method of treating pumping wells with an inhibitor consists of introducing the chemical down the annulus between the casing and tubing. No attempt was made to survey specific treating methods, such as use of pumps, lubricators, tank trucks, etc., but the treating frequency was found to be as follows:

Continuous	10%
Batch daily	55
Batch 6 days/week	13
Batch 5 days/week	7
Batch twice a week	15

A segregation of the inhibitors used showed that 65 percent were classified as inorganic (mainly arsenite and chromate) and 35 percent organic. No significant difference in effectiveness was apparent between the two classes of inhibitors. Cost of treatment, chemical plus labor for injection, was reported for two-thirds of the wells in the survey and averaged $30.50 per month.

One helpful control used for inhibitor effectiveness is the iron analysis of the produced fluid. Iron count data before and after treatment were available on two-thirds of the wells. The figures showed an average reduction of 80 percent in the iron content of the production. None of the wells were reported as producing appreciable amounts of H_2S.

Effect of Water Percentage

Although about half of the wells are in the 90-100 percent cut bracket (Figure 3), it was thought that a study of the influence of water percentage on pull-

★ A paper presented at the Tenth Annual Conference, National Association of Corrosion Engineers, Kansas City, Mo., March 15-19, 1954.
* Now T1-K-1 (Pacific Coast).

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PRESTON W. HILL—Engineer with Signal Oil and Gas Company, Los Angeles. A graduate in chemical engineering from Northeastern University, Boston, 1925, he has been active in engineering and research projects in the California petroleum industry. A long time member of the Southern California Meter Association and the California Natural Gasoline Association, he has been active also in technical committee work for the National Association of Corrosion Engineers.

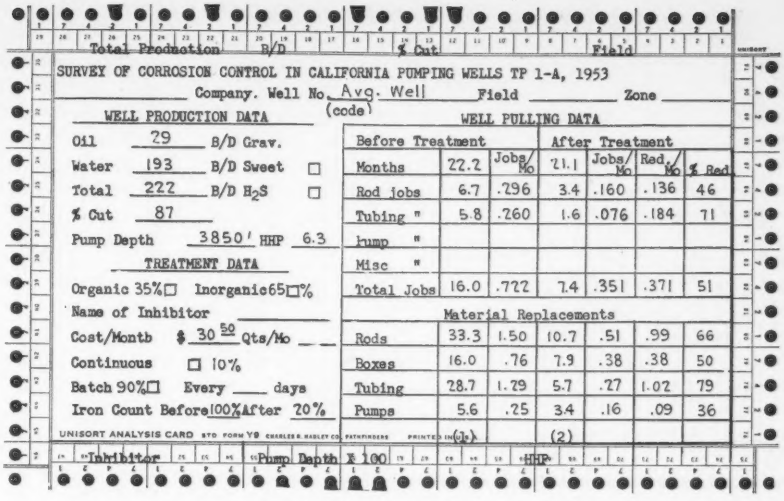
Abstract

This paper summarizes the results of corrosion control in a representative group of California wells. The data were furnished by the members of TP-1A Committee on Corrosion of Oil & Gas Well Equipment, California and were collected and correlated using hand-sort punch cards. Information obtained from 17 fields and 14 companies covers some 350 wells on which complete data were available. The wells vary from 1000 to 8000 feet in pump depth and produce up to 1000 b/d gross.

The survey indicates that the use of various inhibitors has so far resulted in an average of 50 percent reduction in pulling jobs. Material replacements are reduced by an even greater percentage.

ing frequency and inhibitor effectiveness would be of interest. The cards were sorted into ten groups by cuts and a tabulation was made of the well pulling data and material replacements before and after treatment and is shown in Table 1.

In preparing the questionnaire, space was provided for reporting pulling jobs due to pump changes and miscellaneous reasons (such as bailing) in order to provide a balanced total. In analyzing the cards, however, these two pulling job classifications were not tabulated because it was believed that the data on pump replacements would be more informative than the pulling jobs for pump changes since pumps often are replaced when a well is pulled for rod or tubing failures.


SURVEY OF CORROSION CONTROL IN CALIFORNIA PUMPING WELLS TP 1-A, 1953

Company. Well No. Avg. Well (code) Field Zone

WELL PRODUCTION DATA

Oil 29 B/D Grav.
Water 193 B/D Sweet ☐
Total 222 B/D H_2S ☐
% Cut 87
Pump Depth 3850' HHP 6.3

TREATMENT DATA

Organic 35%☐ Inorganic65☐%
Name of Inhibitor
Cost/Month $ 30.50 Qts/Mo
Continuous ☐ 10%
Batch 90%☐ Every ___ days
Iron Count Before100%after 20%

WELL PULLING DATA

	Before Treatment		After Treatment			
Months	22.2	Jobs/Mo	21.1	Jobs/Mo	Red./Mo	% Red
Rod jobs	6.7	.296	3.4	.160	.136	46
Tubing "	5.8	.260	1.6	.076	.184	71
Pump "						
Misc "						
Total Jobs	16.0	.722	7.4	.351	.371	51
Material Replacements						
Rods	33.3	1.50	10.7	.51	.99	66
Boxes	16.0	.76	7.9	.38	.38	50
Tubing	28.7	1.29	5.7	.27	1.02	79
Pumps	5.6	.25	3.4	.16	.09	36

UNISORT ANALYSIS CARD STD FORM Y8 CHARLES R. HADLEY CO. PATHFINDERS PRINTED IN U.S.A. (1) (2)

Total Production B/D % Cut Field Inhibitor Pump Depth X 100 HHP

Figure 1—Questionnaire showing data for average well in survey.

The more significant data in Table 1 were plotted and are shown in Figures 4, 5, 6 and 7. Figure 4 is the frequency of pulling jobs for all causes plotted against the average percentage cut of the wells in each cut group. This graph shows that in general the pulling frequency before treatment increases with the percentage of produced water. The area between the before and after treatment curves clearly illustrates the effectiveness of the treatment program which has reduced total pulling jobs for all reasons by an average of 51 percent.

Figure 5 is a similar graph for rod job frequencies plotted against cut. This also shows a general increase in job frequencies before treatment with increasing cut, except for a sharp increase in frequency for the wells in the 50-60 percent group. It was thought at first that this high pulling frequency might be due to the influence of wells from a particular field but a review showed that most of the fields are represented. This group of wells responded readily to treatment, while the next group, 60-70 percent cut, did not respond and showed an increase in rod jobs.* The reduction in rod jobs for all wells that was accomplished by inhibition was 46 percent. However, the reduction in rod replacements was considerably higher (averaging 66 percent) which in terms of material was a saving of about 12 rods per well per year.

Figure 6 is a similar graph of tubing job pulling frequencies which shows the same general increase with percent cut before inhibition but a better response to treatment. The reduction in tubing jobs was 71 percent. Because tubing jobs cost at least twice as much as rod jobs, this reduction is even more significant in terms of operating coats. Tubing replacements decreased from an average of 15.5 to 3.3 joints per well per year.

Figure 7 is a graph of pump replacements before and after inhibitor treatment. The indicated response is considerably less than that for rods and tubing, averaging 36 percent reduction. This lower response

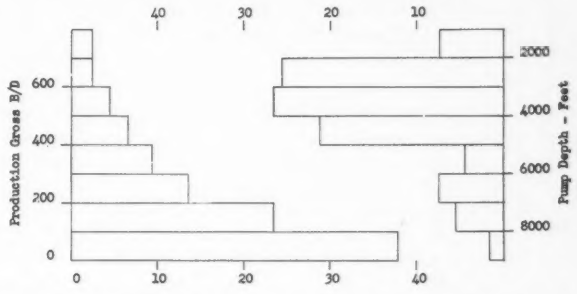


Figure 2—Percentage distribution of wells in survey as to production gross barrels per day and pump depth.

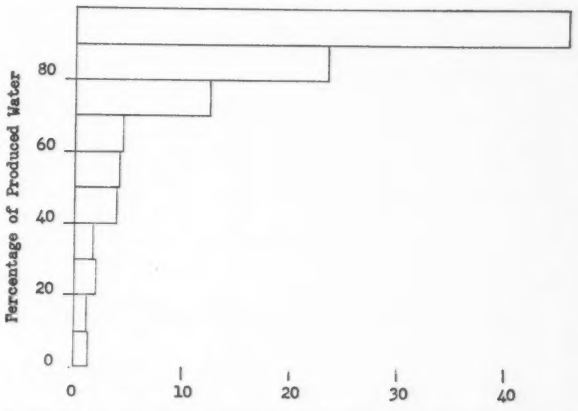


Figure 3—Percentage distribution of wells as to percentage of produced water.

may not reflect any difference in corrosion mitigation, but is probably due to the practice of changing pumps whenever the pump is out of the well, regardless of its condition.

Results by Fields

The questionnaire cards were coded and sorted by fields for analysis of inhibitor response. Results of the analysis are given in Table 2, which shows the

*It was learned subsequently this group of wells included one with an abnormal number of rod breaks after treatment because it was used to test rod grading methods.

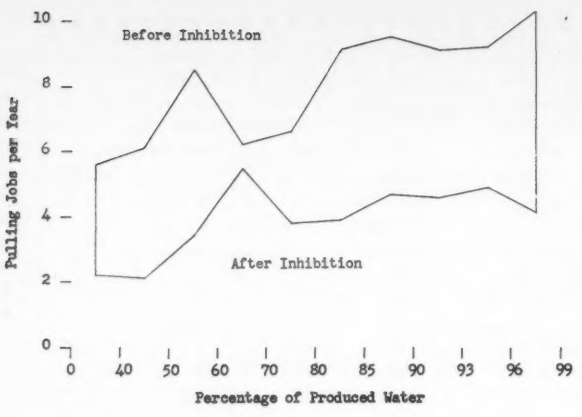


Figure 4—Pulling frequency. Total jobs before and after treatment.

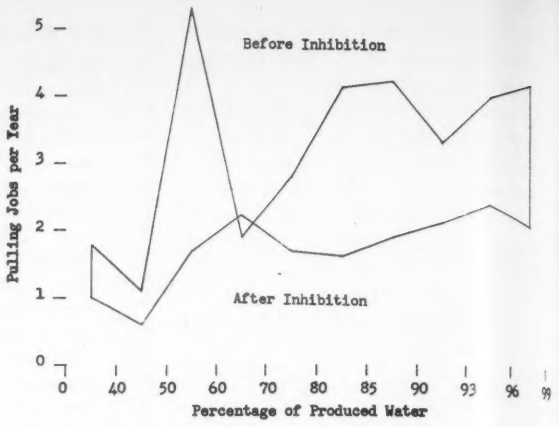


Figure 5—Pulling frequency. Rod jobs before and after treatment.

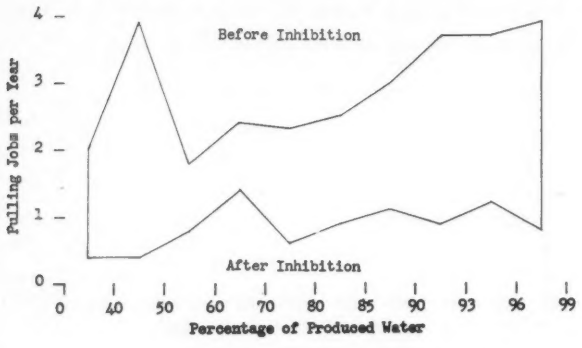


Figure 6—Pulling frequency. Tubing jobs before and after treatment.

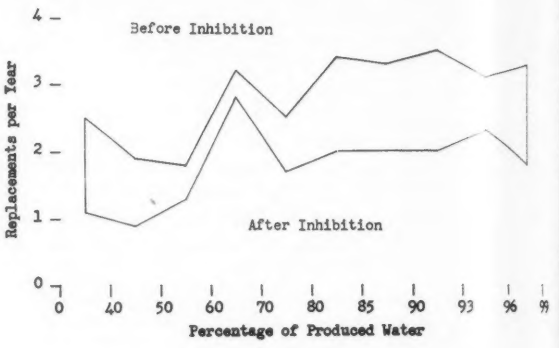


Figure 7—Pump replacements before and after treatment.

TABLE 1

Analysis of Corrosion Control as Related to Water Production

Water Percent of Production	No. of Wells	PULLING FREQUENCY–JOBS/YEAR						MATERIAL REPLACEMENTS/YEAR							
		Rods		Tubing		Total		Rods		Boxes		Tubing		Pumps	
		B*	A*	B	A	B	A	B	A	B	A	B	A	B	A
0-40	18	1.8	1.0	2.0	.4	5.6	2.2	9.1	4.4	7.8	2.1	10.0	.7	2.5	1.1
40-50	14	1.1	.6	3.9	.4	6.1	2.1	10.4	3.9	5.6	3.0	14.4	.5	1.9	.9
50-60	15	5.3	1.7	1.8	.8	8.5	3.4	28.7	11.2	1.8	2.5	4.2	.8	1.8	1.3
60-70	15	1.9	2.2	2.4	1.4	6.2	5.5	13.8	14.5	4.3	.6	12.6	3.2	3.2	2.8
70-80	44	2.8	1.7	2.3	.6	6.6	3.8	16.6	7.1	7.5	1.9	10.6	1.1	2.5	1.7
80-85	37	4.1	1.6	2.5	.9	9.1	3.9	12.3	5.1	6.2	3.3	12.6	2.2	3.4	2.0
85-90	46	4.2	1.9	3.0	1.1	9.5	4.7	20.2	6.9	7.1	5.1	12.8	3.3	3.3	2.0
90-93	45	3.3	2.1	3.7	.9	9.1	4.6	18.8	4.5	6.3	5.4	18.1	3.2	3.5	2.0
93-96	61	4.0	2.4	3.7	1.2	9.2	4.9	20.5	7.1	14.6	6.7	17.9	5.0	3.1	2.3
96-99	53	4.2	2.1	3.9	.8	10.3	4.1	17.8	5.2	12.2	6.3	23.8	4.4	3.3	1.8
ALL	348	3.5	1.9	3.1	.9	8.6	4.2	18.0	6.1	9.1	4.5	15.5	3.3	3.1	2.0
Percent Reduction		46		71		51		66		50		79		36	

B* = Before Treatment A* = After Treatment

TABLE 2

Analysis of Corrosion Control by Fields

FIELD	No. of Wells	Pump Depth	Gross B/D	Water Percent	PULLING FREQUENCY–JOBS/YEAR						Pumps Replaced per Year	
					Rods		Tubing		Total			
					B*	A*	B	A	B	A	B	A
Long Beach	93	4180	281	91	4.3	2.6	3.3	1.2	10.2	6.0	3.7	2.9
Huntington Beach	77	3240	161	79	1.9	.7	2.6	.6	5.5	1.9	1.7	.7
Midway-Sunset	54	2850	97	82	1.5	1.3	3.7	.6	7.1	3.2	2.1	1.4
Wilmington	33	4380	272	83	3.7	1.4	4.1	.6	9.7	3.1	3.2	1.3
Santa Fe Springs	28	6350	310	85	11.7	4.1	1.7	.7	16.6	7.5	5.2	3.9
Dominguez	18	4980	293	90	3.6	1.5	1.9	1.0	7.8	4.1	2.9	2.2
Ellwood	10	4460	262	88	7.0	5.7	.6	.6	8.3	6.8	.8	.3
Inglewood	10	2320	73	74	.9	.2	6.0	.8	9.0	2.3	2.1	1.4
Montebello	8	6070	229	93	3.7	1.6	1.8	1.3	6.8	3.7	5.2	3.1
Miscellaneous	17	....	....	....	....	....	....	....	....	....	....	....
Total	348	3850	222	87	3.5	1.9	3.1	.9	8.6	4.2	3.1	2.0
Percent Reduction					46		71		51		36	

B* = Before Treatment A* = After Treatment

average production, cut, pump depth, pulling frequency for rods, tubing, total pulling jobs and pumps replaced. The variations in response from field to field probably reflect such variables as fluid composition and operating conditions. The field with the deepest wells and largest production, for example, had the greatest frequency of rod failures before treatment, while the field with the shallowest wells and smallest production had the lowest frequency of rod failures but the greatest frequency of tubing failures.

Summary

An analysis of the performance of inhibitors in a representative group of California pumping wells shows that well pulling frequencies are being reduced about 50 percent for the average well. Total pulling jobs averaged 8.6 per well per year before treatment, including 3.5 rod jobs and 3.1 tubing jobs. After treatment with corrosion inhibitors, total pulling jobs averaged 4.2 per well per year, including 1.9 rod jobs and 0.9 tubing jobs, an over-all saving of 4.4 pulling jobs per well per year. However, the cost of inhibitor treatment of $366 per well per year must be charged against the savings to obtain the net savings. In order to get some idea of these savings, the labor cost of rod and miscellaneous jobs may be assumed at $100 each and tubing jobs at $200 each, which gives a net saving in labor cost due to treatment of about $300 per well per year. Lowered material replacements increase the savings in maintenance cost and reduction in down time represents additional indirect savings.

The following conclusions may be drawn from the results of this survey of corrosion control:

1. Tubing failures are more readily controlled by the use of inhibitors than rod failures and the savings effected are more than double those for sucker rods.
2. Control of corrosion is profitable because of the large reduction in pulling jobs and material replacements.

Acknowledgments

The authors acknowledge the work and cooperation of the members of TP-1A in preparing the individual well questionnaires and thank the various companies for releasing the data.

DISCUSSION

Question by L. W. Vollmer, Gulf Research and Development Co., Pittsburgh:
Has there been any indication that corrosion inhibitors will equalize the performance of carbon steel and alloy steel sucker rods under the same service conditions?

Reply by Frank Davie:
Although the survey did not include data that would answer this question, some work is being done in California on the comparison of carbon steel and alloy steel sucker rods in inhibited wells. It is our understanding that in these mixed rod string tests the performance of carbon steel rods is at least equal to that of alloy rods. This is a subject that deserves a careful industry-wide study which could lead to a substantial economic saving.

Question by Winfred B. Hirschmann, Whiting, Ind.:
Have you made an estimate of the additional indirect savings due to reduction in down time?

Reply by Frank Davie:
No data were collected on either the crew time required to pull wells or the time a well was idle waiting on a pulling crew, although well kept records report such data. The evaluation of the indirect savings due to reduction in down time would doubtless differ among different operators and fields and we believe that such savings are recognized but not evaluated.

Question by Herman Herst, Chicago:
Was there any correlation between comparative effectiveness of organic or inorganic inhibitors in relation to water production—that is, do inorganic inhibitors show more effectiveness in wells producing large percentages of water?

Reply by Frank Davie:
The authors did not make a detailed comparison of the effectiveness of inhibitors by type in relation to water production. It was believed that such a comparison would not be valid in wells grouped from various fields and producing zones and there were insufficient data on individual fields and zones.

Question by Louis T. Monson, Los Angeles, Cal.:
Will you express an opinion as to the percentage of cases in which inhibitor injection was performed among the wells canvassed by service contractors?

Reply by Preston W. Hill:
About 50 percent.

Question by John Rehner, Jr., Westfield, N. J.:
Was the relative effectiveness of organic and inorganic inhibitors compared?

Reply by Frank E. Davie:
An overall comparison of the two types of inhibitors showed a slight but not significant advantage for inorganic inhibitors in the wells reported.

A Technical Note

A Method of Considering Costs While Selecting Materials for Corrosion Service

By E. F. T. RICE*

Abstract

Three permissible and one prohibitory corrosion loss rating series in inches pentration per year are listed in order of increasing pentration under three class headings. Classes are arranged according to cost of materials. This arrangement of merits versus costs permits selecting materials for corrosion resistant service while simultaneously considering resistance and cost. Allowance is made for pitting through invalidation of two of the classes of approval ratings and transferring the remaining most favorable rating schedule to least favorable. A factor for precious metals is recommended.

TERMINOLOGY with respect to corrosion recommendations is far from exact or consistent. Satisfactory, inert, attacked, resistant, etc., are rather vague adjectives. This, however, is not surprising. Proper evaluation largely depends upon the nature and cost of the substance being corroded. While the loss of a few pounds from lead equipment may be negligible the same loss from equipment made of tantalum would be very costly. On the other hand, the complete loss of a small silver rupture diaphragm cannot be considered equal in economic significance to the failure of a large steel storage tank. Also, thick castings usually can tolerate without serious hazard deeper pits than thinner wrought shapes.

Economic considerations of this kind should be foremost in the design engineer's mind when specifying materials for chemical construction. Few corrosion charts include economic relationships, although there are many reference tables that indicate penetration rates of numerous corrosives versus common metals and alloys. Included herein is a suggested corrosion rating guide that includes the cost factor by providing separate corrosion limits for metals of various price ranges. It is designed for use in connection with corrosion tests or published literature that furnish penetration data.

The limits, expressed in units of inches penetration per year, are conservative figures developed from study of corrosion literature and analysis of hundreds of laboratory and plant tests over the past twelve years.

Actually, many metals are used under more stringent conditions than is justified by their resistance to corrosives simply because sturdier alternatives are prohibitively expensive. This is particularly true of the materials listed in Table 1 under Class II. Nevertheless, in a general guide of this type fairly strict tolerances should be used and certain cases recognized as exceptions.

No attempt has been made to indicate absolute prices of the three classes of metals. The reason is twofold: First, individual prices swiftly become obsolete and second, the price depends upon the specific alloy, structural shape, heat treatment, finish, etc. Furthermore, the cost of the metals relative to one another will not vary significantly; certainly not enough to warrant changes in the broad groupings.

The classification is based upon average costs of materials for chemical construction. Class III includes the few relatively cheap, and Class I the few relatively expensive, metals commonly used by the chemical industry. Class II lists the larger number of metals and alloys used for corrosion resistance that fall between these extremes in cost. A special "precious metals" classification has been made for those materials which, due to their value, must be virtually inert to a corrosive in order to be considered. The familiar E, G, F, NG abbreviations connote Excellent, Good, Fair and No Good, but are further defined.

It is well known that pitting corrosion invalidates calculations based on uniform penetration. This fact is acknowledged in the corrosion rating guide by eliminating the E and G designations when pitting is encountered and transferring the normal E limits to F. Hence, where pitting is encountered this corrosion rating guide recommends "use only under special conditions for short exposure."

Like any corrosion rating system, of course, it must be recognized as a guide only; an intelligent means of narrowing the field of choice. Absolute performance, when required, must be determined by actual field tests which reflect all the elusive factors contributing to corrosion: aeration, velocity, temperature, concentration, stress, electrolytic effects, trace contaminants, etc.

TABLE I—Merits Of Materials vs. Cost

Note: Pitting invalidates G and F limits and transfers E limits to F. For platinum, gold, tantalum and zirconium divide Class I limits by 5.

RATING	Class I[1] IPY	Class II[2] IPY	Class III[3] IPY
E –Entirely satisfactory	0–0.003	0–0.005	0–0.009
G –Use with caution	0.003–0.006	0.005–0.012	0.009–0.030
F –Use only under special conditions for short exposure	0.006–0.010	0.012–0.020	0.030–0.055
NG–Do not use	>0.010	>0.020	>0.055

[1] Silver, tin, Hastelloys, chlorimets, Illium, titanium, etc.
[2] Stainless steels, Monel, nickel, Inconel, Durimets, Everdur, Duriron, Durichlor, Stellite, copper, magnesium, bronzes, aluminum, etc.
[3] Steel, cast iron, lead, brass, zinc, etc.

★ Submitted for publication November 24, 1952.
* 416 Goodley Road, Wilmington, Del.

A Promising Spray-Applied Inhibitor Of Internal Corrosion of Oil Tank Ships*

By J. D. SUDBURY,[1] D. A. SHOCK[2] and F. W. MANN[3]

Abstract

After reviewing briefly the characteristics, type of cargo and capacities of oil tank ships operating between Gulf and East Coast ports, the estimated cost of internal corrosion of the existing United States tanker fleet is estimated at $360,000,000 during the next 20 years. Causes of corrosion in tank compartments are scanned and current protective methods discussed.

Laboratory experiments using coupons are described in which soluble oil, sodium dichromate, sodium nitrite, benzoic acid and a commercial organic inhibitor are tested. Because of the good showing made by a sodium alkyl aryl sulfonate inhibitor formulations incorporating calcium sulfonate and sodium sulfonate with rosin amine stearate as a tackifying agent were tested. The best formulation was adopted for shipboard tests which are now in progress. Efforts are being made to find hydrocarbons with lower flash points.

Introduction

THERE are many ocean-going oil tankers actively engaged in transportation of crude oil and its refined products. Figure 1 shows a type of tanker. This type is among the most common in the present day world tanker fleet. A large portion of the expense of operation of these ships can be attributed directly to corrosion. Corrosion takes place on the exterior of the ships, in the various pipes and in the cargo compartments.

This discussion will be limited to a study of the corrosion in the cargo compartments of a type T-2 tanker in coastwise service carrying refined products between the East Coast and the Gulf Coast. These ships normally are loaded on the Gulf Coast with a series of refined products and carry the load to one of the East Coast ports, where it is discharged. The return trip is made with most of the cargo compartments empty and a few of the compartments filled with sea water as ballast. These tanks are thus exposed to an intermittent cycle of exposure to petroleum products and then to either sea water or a humid sea atmosphere.

Figure 2 illustrates a typical plan view of a T-2 tanker. The ship is roughly 65 feet by 500 feet and has a dead weight carrying capacity of 16,000 tons. The cargo tanks are three abreast throughout most of the length of the ship. The wing tanks hold 4000 barrels each and the center tanks 8000 barrels each; thus there is a total capacity of 128,000 barrels plus that of two small tanks in the bow. A typical cargo load would have heating oil in tanks 1, 2 and 3; kerosene in 4 and 5; and gasoline in 6, 7, 8 and 9. When empty, several tanks, such as 2, 5 and 8 may be used for ballast. Void spaces known as cofferdams separate the cargo compartments from the ship's fuel tanks, which are designated as bunkers and from the dry storage areas.

The simplified sketch of the interior of a typical cargo tank shown in Figure 3 does not illustrate the very complex nature of cargo tank interiors. Failures in these tanks are due to reduction in thickness of the compartment walls and of the structural bracing. These failures are more pronounced in ships in so called clean service (that is those carrying refined products) than in ships in dirty service carrying crude petroleum. After about 7-10 years clean service, corrosion is usually sufficiently advanced that the ship must be taken out of clean service and put in the less corrosive dirty service or the ship owners must prepare to spend large sums in repairs of failures due to corrosion. The normal useful life of a ship is considered to be about 20 years. The cost of repairs to extend the life of a ship in clean service to

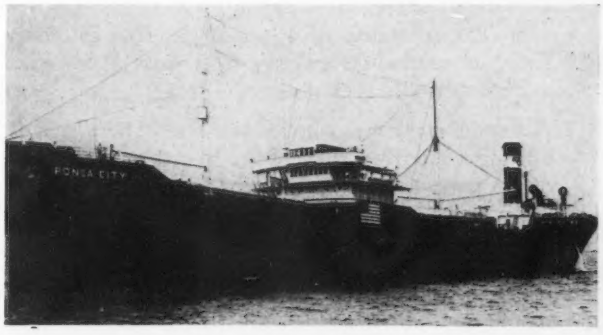


Figure 1—An oil tankship.

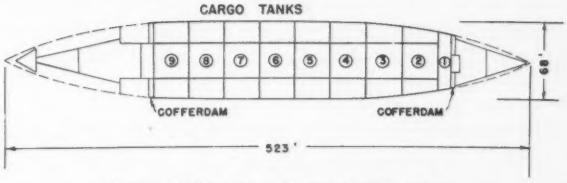


Figure 2—Plan view of typical T-2 tanker.

★ A paper presented at a meeting of South Central Region, National Association of Corrosion Engineers, New Orleans, La., Oct. 1-3, 1952.

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20 years was recently estimated at $400,000 by the Shell Oil Company.[1] In CORROSION,[2] June 1952, Cranmer of the Navy Department, estimated that $200,000 to $300,000 would be spent on corrosion repairs after 10 years of clean service. More pessimistic estimates have indicated the possibility of expenditures of as much as $1,000,000 after 10 years in clean service.

In order to get some rough estimates of the total annual cost of corrosion to the tanker industry, a few rough calculations are outlined below. These calculations are based on estimates by Benedict Saurino, Statistical Research Division of Sun Oil Company.

Total Tankers (1952 est.)	1700
Total Tankers in clean service	900
Minimum corrosion costs to maintain ship in clean service for twenty years.$	400,000
Industry cost for next 20 years	360,000,000
Annual cost of corrosion	18,000,000

This figure is potentially even worse for the next five years. About 50 percent of all tankers in service at present were built during the war years and are now 6 to 10 years of age and are just reaching the point where extensive corrosion repairs must be made on those ships in clean service.

Causes of Corrosion in Compartments

Corrosion in cargo compartments is a result of the oxidation of iron when exposed to a water and oxygen atmosphere resulting in the formation of ferrous hydroxide, which is then oxidized to iron rust as a corrosion product. This mechanism has been previously discussed[3] by Aaron Wachter of Shell Oil Company and need not be expanded at this time.

Several probable sources of these corrodents can be listed:

1. Dissolved water and oxygen in petroleum products. The solubility of water in gasoline has been listed as several gallons per 1000 barrels and oxygen solubility is even greater.
2. A humid, oxygen-saturated sea atmosphere that is introduced during the normal breathing processes of the tank.
3. Introduction of sea water as ballast.
4. The process of Butterworthing the compartments. This is a standard procedure involving the spraying of hot water at pressures of 100 psi. Its purpose is to clean the tanks of residual cargo and loosely adhering deposits of corrosion products.

All these factors except the first tend to make the corrosion problem more severe during the portion of voyage in which the ship is not loaded with cargo.

Discussion of Protective Systems Now Being Used

Several different approaches are now being made by various organizations in an effort to combat this very severe problem. The more significant of these can be listed.

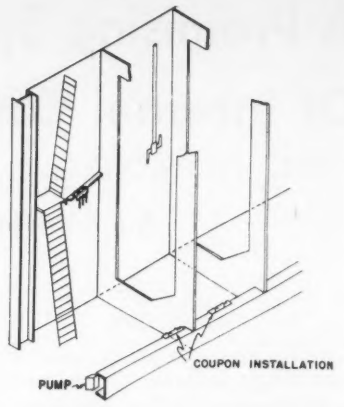

Figure 3—Simplified sketch of typical cargo tank interior.

1. Treatment of all the cargo with a corrosion inhibitor. This should give excellent protection while the cargo is aboard and possibly some slight residual protection during the time the tanks are empty. Assuming a dosage of 20 ppm at a cost of 25c per pound, this type of treatment would cost $250 for each shipload of cargo. This would amount to $5000 to $6000 per year for treatment of a ship in coastwise service.
2. Tank coatings—Some work recently completed for the Navy[2] evaluated several different coatings for service on tank ships. The results of this work showed Saran coatings to be the best of several coatings evaluated. Saran appears to give satisfactory protection if applied on a sandblasted surface and if touched up about every 30 months. However, the cost of such an application makes its use seem prohibitive at the present time, except on specialty parts.
3. Spray systems—Sodium dichromate or alkaline sodium nitrite sprays have been used on a number of ships recently. The inhibitors are sprayed after each unloading of cargo by either a fixed system of sprays installed permanently in the ship or by use of spray nozzles, such as are used in the Butterworthing process. Both of these chemicals are established as being effective in preventing atmospheric corrosion. The sodium dichromate has been used as a spray in tanks containing considerable residual leaded gasoline, resulting in the precipitation of the inhibitor as lead chromate. Its use seems limited in ships carrying refined products. Laboratory tests indicate that the sodium nitrite solution has only a limited lasting effect when sprayed on a steel surface exposed to sea water atmosphere. Field tests indicate some protection is slowly built up on corroded surfaces.
4. Magnesium anodes have been used with reported success in controlling corrosion in ballast tanks; however, they are obviously not useful in empty tanks.
5. A system for maintaining an atmosphere of dry air in the empty cargo compartments is now being used experimentally on several ships. The water is removed by passing the air through silica gel beds. By holding the relative humidity of the air below 50 percent, it is claimed that corrosion can be reduced by 80 percent. The initial cost of such an installation on a T-2 tanker is about $70,000 but the cost of maintenance is very low. This method of corrosion control appears to have considerable merit if the dehumidified atmosphere can be satisfactorily maintained in the tanks. However, on short trips, it is doubtful if the tanks can be dried out much before arrival at the next port.

Experimental

Investigation of all the available treating systems led to the conclusion that there is not yet available a system capable of giving the desired protection. It is believed, however, that the idea of spraying the compartment walls is basically a very good approach toward economical solution of the problem.

Inhibitor Screening Tests—With this method of attack in mind, a preliminary series of screening tests was set up in order to determine types of chemical treatment that could be used successfully in reducing the corrosivity of air-saturated sea water. The apparatus shown in Figure 4 involved a system for passing air through a series of bottles filled with sea water treated with different inhibitors. Corrosivity was measured by immersion of corrosion test coupons for two days. Some of the data obtained in these tests are shown in Table 1.

These data indicate that, in addition to proved oxygen corrosion inhibitors such as sodium dichromate and alkaline sodium nitrite, a soluble oil-type material was shown to be extremely effective in reducing corrosion rates. The commercial organic inhibitor, shown to be ineffective, represents the type of inhibitor successfully used in combatting corrosion in oil and gas wells where no oxygen is present.

Inhibitor Spray Tests.—After showing that several types of material are effective inhibitors, an apparatus was set up to more closely evaluate the effectiveness of an intermittent spray treatment in preventing corrosion on steel surfaces exposed to a corrosive atmosphere. A photograph of this apparatus is shown in Figure 5.

TABLE 1—Corrosion Inhibitor Screening Tests

Inhibitor (0.1%)	Percent Protection
Soluble Oil	97
Sodium Dichromate at pH = 10	93
Sodium Nitrite at pH = 10	91
Benzoic Acid at pH = 10	45
Commercial Organic Inhibitor	10

TABLE 2—Inhibitor Spray Tests

Spray Solution	Percent Protection
Soluble Oil, 0.1%	—3
Soluble Oil, 5%	89
Sodium Dichromate at pH = 10, 0.1%	38
Sodium Dichromate at pH = 10, 0.5%	47
Sodium Nitrite at pH = 10, 0.1%	1
Sodium Nitrite at pH = 10, 10%	24
Sea Water	—18

TABLE 3
Effectiveness of Inhibitor Sprayings in Reducing Atmospheric Corrosion

Inhibitor Formulation:

Sulfonate*	Tackifying Agent	Carrier	Per Cent Protection
5 Percent calcium sulfonate*	0.5 Percent rosin amine stearate	naphtha	99.8
5 Percent sodium sulfonate	0.5 Percent rosin amine stearate	naphtha	96.
5 Percent sodium sulfonate	0.5 Percent rosin amine stearate	water	94.
5 Percent sodium sulfonate	0.1 Percent rosin amine stearate	water	83.

* Sulfonates are only 25-30 percent active ingredient.

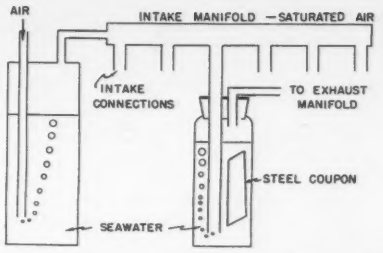

Figure 4—Apparatus for screening inhibitors for sea water service.

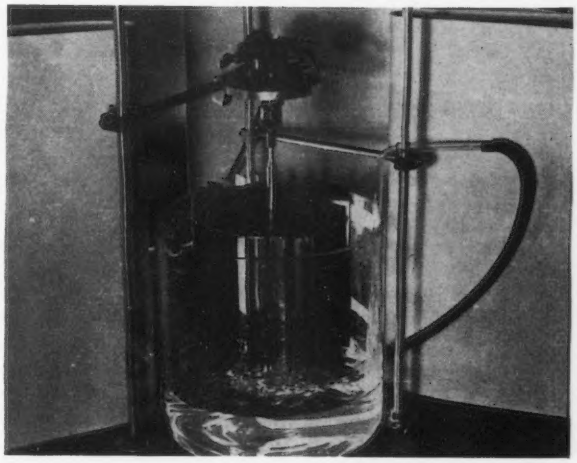

Figure 5—Apparatus for evaluating spray-type inhibitors in corrosive marine atmosphere.

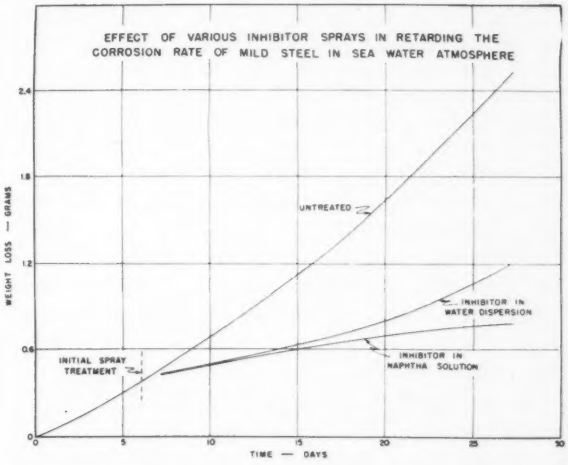

Figure 6—Effect of intermittently spraying coupons previously exposed to a corrosive salt spray.

As many as 16 coupons can be placed on the rack which slowly rotates above a sea water solution. Air is bubbled through the sea water in order to accelerate the corrosivity of the atmosphere above the water. In each run several untreated coupons were exposed for comparison purposes. Each of the other coupons was individually sprayed using a spray gun operated with 100 psi air pressure. Coupons were ex-

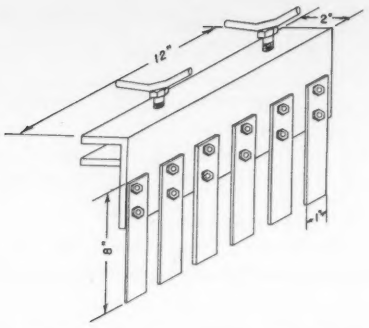

Figure 7—Coupon rack for installation in cargo compartment.

posed for a period of five days and were then descaled and corrosion rates measured in terms of weight losses. Percentage protection for each spray system was calculated by comparison with the untreated coupons.

Table 2 shows some representative data from the series of tests. It is readily seen that the sodium nitrite, dichromate and soluble oil treatments in the concentrations previously used are not nearly so effective in the intermittent spray system as in the original system when the coupons were completely immersed for the duration of tests. Further tests show that, when the concentration of the soluble oil reaches about 5 percent, very good and lasting protection was established. Increased concentration of the others did not lead to adequate protection. Modifications of the original soluble oil-type inhibitors have led to better protection at lesser concentrations.

It has been shown that one of the most effective of the soluble oil type materials has been a sodium alkyl aryl sulfonate with an average molecular weight of about 450. Such a product is sold by The Bryton Chemical Company, Marcus Hook, Pennsylvania. It has further been shown that the addition of certain gelling or tackifying agents greatly improves the effectiveness and longevity of the protective film of sulfonate.

Further work has proved that if the inhibitor can be sprayed as a solution in a hydrocarbon carrier protection is better than when sprayed as a dispersion in water. Some of the formulations which have been particularly successful are summarized in Table 3. The sulfonates are as sold by The Bryton Chemical Company.

All the tests discussed thus far have been made using clean abraded steel coupons. A further series of data was obtained by intermittently spraying coupons that had been previously corroded in the salt spray. The results of these tests are shown in Figure 6 where weight loss in grams is plotted against time. All coupons were left untreated and exposed to the corrosive atmosphere for the first 7 days. After this all the coupons except four control coupons were sprayed after each 7-day exposure to the corrosive atmosphere. The top curve represents the corrosion curve of untreated coupons. The other curves represent the reduction in corrosion rate brought about by spraying with several different soluble oil type formulations. It is readily seen that the corrosion rate of corroded specimens is greatly reduced by the spray treatments.

Shipboard Tests—As soon as the laboratory work had progressed far enough to indicate the practicality of treating cargo tanks for corrosion by intermittent spraying, plans were made to evaluate the effectiveness of the treatment by use of corrosion coupons in four carefully controlled experimental compartments on a T-2 tanker. Two of the test tanks chosen normally carry ballast. One each of the ballast and non-ballast tanks was left untreated for comparative purposes. It was planned that the other two be sprayed immediately after each discharge of cargo.

In order to evaluate the corrosion rates, test coupons were installed in each of the four experimental compartments. Figure 7 shows one of the coupon racks loaded and ready for installation aboard the ship. The installation involves only slipping the channel over an edge of one of the tank longitudinal U-beams and the hand tightening of the T-handle bolts. The coupons were 1-inch by 8-inch specimens cut from a sheet of 14-gauge cold rolled mild steel. The surfaces were prepared by abrasion on a belt sander. The location of the coupon holders inside an experimental tank can be seen in Figure 3. One holder is placed near the top of the tank, one at the bottom where it will be hit with a direct stream from one of the spray nozzels and one in a position out of the direct stream such that the coupons can be wet with inhibitor only by an indirect splashing effect. It was planned that one coupon should be removed each month.

Treatment of the Ship—In the original spray tests a batch of inhibitor dispersed in 200 barrels of fresh water was used to spray the compartments. The spray solution was mixed and stored in the after starboard cofferdam. Suction is taken from this cofferdam by the steam cargo stripping pump, the material is discharged into the steam supply line on deck to the heating coils, thence through the Butterworth machines into the cargo tanks, then returned to the after starboard cofferdam with the electric cargo stripping pump. Figure 8 shows a sketch of the type spray nozzels used on all tank ships for cleaning purposes. When liquid under pressure is forced through, the nozzles rotate as indicated by the gears and also rotate around the axis of the device so that the entire interior surface of the tank can be wet in a few minutes.

It was necessary to install a filter just back of the nozzles in order to prevent their being plugged by solid rust particles picked up during the cycling process. Each tank was sprayed for about 15 minutes. Visual examination of the interior of one of the tanks after spraying showed essentially complete coverage of the entire compartment interior. Even the surfaces that are not in direct line with the spray at any time seem to be wet by an indirect splashing effect. Each nozzle of the dual-nozzle system sprays about one

barrel per minute under 100 psi pressure. There are normally two of these in operation, allowing the spraying of five to eight tanks per hour; thus the ship's 26 tanks can be sprayed in four to five hours.

Some of the coupon data obtained during four months of preliminary tests can be briefly reviewed. Figure 9 summarizes coupon data showing the relative rates of corrosion in untreated cargo and ballast tanks. It is noted that the corrosion rate in the ballast tank is several times higher than in the empty cargo tank. In the empty tank, the rate is a little more severe on the bottom of the tank; but corrosion seems to proceed at a fairly steady rate throughout the compartment. In the ballast tank, the corrosion rate on the bottom seems to slow down as a hard adherent protective scale is developed. At the top, however, where the coupons are alternately in and out of the ballast water, the corrosion product is loosely attached and corrosion continues at a rapid rate.

These data are contrary to other published results which state that the corrosion rate in ballast tanks is negligible. This certainly is not true in the tops of the tanks.

There is one factor that makes these comparative rates somewhat in error. When a tank is filled with ballast, it is noted that the sides of the bulkhead walls in adjacent empty compartments soon become wet due to condensation. This undoubtedly accelerates the corrosion rates in the empty tanks. The coupon installation as made cannot detect accelerated rates due to this condensation effect.

Corrosion rates in the untreated tanks were compared with two tanks being sprayed with solution of an inhibitor spray. As expected from the laboratory results this low concentration gave very little protection in the initial stages of treatment. After about three months, however, the spray treatment apparently became effective in reducing corrosion in both cargo and ballast tanks. These data were considered as only a qualitative indication and are not published.

After these preliminary tests, a laboratory-developed formation (Conoco T-20 tanker inhibitor) was substituted for the dilute soluble oil treatment. The cargo compartment interiors were sprayed four times during a 2-month test with a 5 percent water dispersion of T-20. The coupon results from a treated and untreated tank are shown in Figure 10. These data show a 75 percent decrease in corrosion rate in the treated tanks. In the normal discharge of cargo prior to spray treatment, it was noted that it is impossible to pump all of the cargo or inhibitor from the cargo compartments. Thus there is a dilution effect each time inhibitor is sprayed in a tank and recirculated through the gathering system. This dilution effect apparently ranges from 5 to 50 percent.

It was necessary to show that the cargo could not be harmed by contamination with inhibitor remaining in the bottom of each tank. Using much larger concentrations than could be expected to occur on the ship, it was impossible to discover any adverse effects of this type inhibitor on the color, gravity, or gum forming characteristics of refined products. It was shown that hydrocarbon contamination did not affect the inhibiting qualities of the soluble oil.

It is, however, important that the dilution not decrease inhibitor concentration below that required to establish protection. To control this factor samples of spray will be collected after each voyage. These

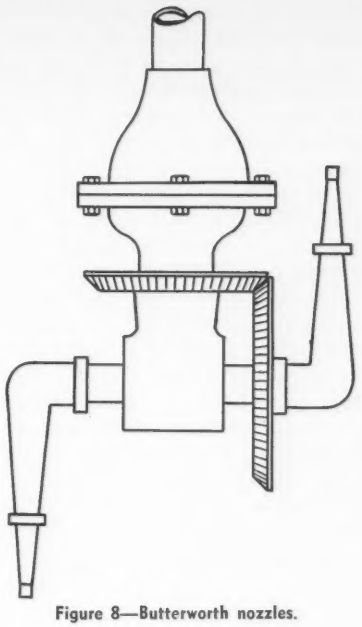

Figure 8—Butterworth nozzles.

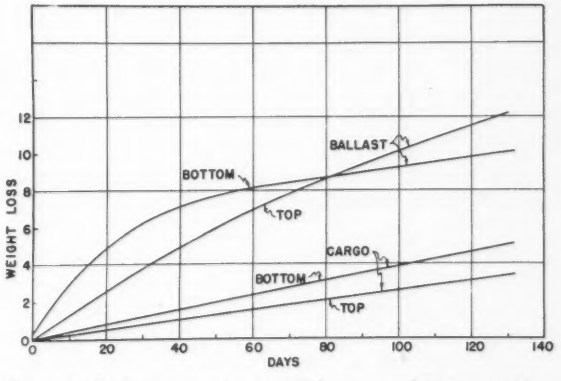

Figure 9—Corrosion rates in untreated cargo and ballast tanks.

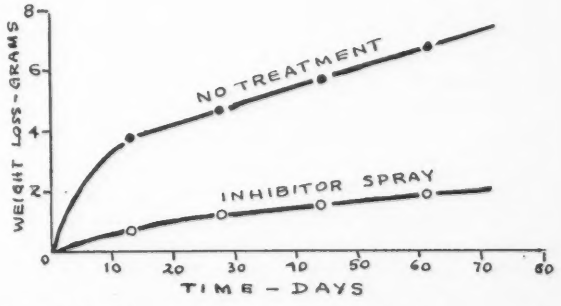

Figure 10—Corrosion rates in treated and untreated cargo compartments.

will be used in the laboratory test system to check their inhibition qualities. When the solution becomes too dilute, additional inhibitor must be added.

On the basis of these data one company tank ship is now being treated on a routine basis. The results of this treatment will be followed closely in order to properly evaluate results of the treating program. As shown earlier by laboratory results, the use of a volatile hydrocarbon carrier for the inhibitor is considerably superior to water. This type treatment is now being used on a second company tankship.

The hydrocarbon now being used in these tests has a flash point in the range of gasoline and its use in these tests has been approved by the Coast Guard. Admittedly this spray mixture is flammable. However, the hazards created are not believed to be any greater than those involved in the routine handling of gasoline on tank ships. Further laboratory tests are now being conducted in an effort to get suitable solvents which do not have low flash points. At least a year of routine treatment will be required before comparative economic savings by use of the water and hydrocarbon base sprays can be made.

Conclusions

The work discussed has not been completed and it is not meant that this paper should indicate a tailor-made method for elimination of corrosion on tank ships. It is believed, however, that several definite conclusions can be drawn from the work which has thus far been completed:

1. A suitable laboratory system has been established for evaluation of spray treatments for use in cargo tanks of any other petroleum storage facilities where corrosion is a problem.
2. Test coupons are an adequate measure of corrosivity in cargo tanks if used under carefully controlled conditions.
3. Spray systems such as are normally used in Butterworthing operations are adequate for spraying cargo compartments with corrosion inhibitors.
4. Chemical formulations developed in the laboratory and applied as sprays are shown to be effective in greatly reducing corrosion rates within cargo compartments of oil tank ships.

Finally, it should be reemphasized that corrosion on ocean-going tanks is costing a tremendous sum of money, a large part of which could be saved by a carefully controlled corrosion mitigation program throughout the industry. It is believed that considably more research effort of the type discussed above can be profitably applied to the further study of this problem. The actual economic savings that can be obtained by an adequate corrosion control program can be proved only over a period of several years.

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Beginnings of Corrosion Prevention*

By ROBERT H. POPE*

PRIOR to the advent of electrically operated street cars, corrosion of underground metallic structures was accepted as a necessary evil and replacements or repairs were made as required without much thought of preventing recurrence of the trouble. With trolley cars in operation such troubles increased materially and consideration was given to preventive measures.

Apparently it always has been a prerogative of the trolley companies to create large earth currents as "necessary to their operations." By the time it was realized how damaging these earth currents could be and that improved design and construction could eliminate much of it, the prerogative was firmly established.

The use of electric power to propel street cars started about the same time as the use of lead sheathed underground telephone cables. Initial trolley design called for connection of the positive bus of the generators to the trolley rails and the negative bus to the trolley wire. Of course, direct current was used because alternating current for such uses was not developed until many years later. As a matter of fact, alternating current was practically unknown at that time. The rails acted as the positive conductor from generator to cars and the trolley wires as the negative lead from cars to the negative bus. Thus the "direction of current" was from generating station to cars in the rails. These rails were usually partly buried and some electricity (frequently a considerable part of the total) escaped from the rails to take a parallel path through the earth. The current which used the earth path became known generally as stray current, but also was called vagabond current.

With the original generator connections, stray currents were directed away from the generating stations which were usually located near the centers of towns, toward the outskirts. Underground metallic structures picked up a share of the stray electricity in the center of town, thus receiving free cathodic protection in this area. This electricity returned to earth in its path back to the rails in the fringe area creating a corrosion exposure on the structures. While relatively mild, this exposure soon caused a large increase in corrosion troubles and consideration was given to methods of prevention or at least alleviation.

In those days the headquarters for the Bell Telephone System or its predecessor, The American Bell Telephone Company, was located in Boston, where Alexander Graham Bell conducted his original experiments leading to the invention of the telephone. Boston pioneered the use of electric power for street cars as well as the use of underground telephone cables and therefore the Bell System's earliest experiences with underground corrosion occurred there.

In what is probably the first case of cooperation among utilities on a corrosion problem, the owners of underground structures together with the trolley company studied the situation at Boston. They realized that the corrosion caused by the stray current would be eliminated if the electricity could be conducted back to the trolley rails metallically instead of through the earth. However, the small difference of potential between the structures and the rails and the large area involved made this impracticable. It was then suggested, apparently by a Mr. Farnham of the telephone company, that the generator polarities be reversed so that rail current and resultant stray current would be toward the generating station.

The trolley company agreed to make the suggested change and this created a reversal of conditions on the underground structures so that now the fringe area received mild cathodic protection while in the vicinity of the substation a severe but concentrated corrosion area was created. However, the structure-to-bus potential became large enough that when a heavy wire was connected between structure and bus sufficient current was carried to eliminate or reduce the corrosion exposure.

Removal of electricity from an underground structure by an electrical conductor for the purpose of corrosion prevention was referred to as "draining" stray current from the structure and the conductor was called a "drainage wire." This nomenclature was used for many years and has persisted into the days of cathodic protection.

★The second in a series of six articles on early developments in cathodic protection and corrosion mitigation measures on underground structures.

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Selecting Gaskets to Limit Corrosion Of Stainless Steel Bolted Joints In a Chemical Plant*

By E. V. KUNKEL

THE MAGNITUDE of the effects of corrosion of austenitic stainless steel gasket bearing surfaces is extremely important to industries using these steels as materials of construction. To those who have experienced this type of deterioration on equipment the effects are well known. Loss to industry as a result of gasket surface corrosion at its worst may be accounted for in loss of product due to leakage, exposure of personnel to hazardous conditions, lost production due to unscheduled shutdowns of units or plants, increased maintenance of equipment and eventual replacement of such deteriorated equipment. All types of equipment which contain gasketed closures or joints may be subject to this type of attack and it is commonly found in piping, heat exchangers, fractionation towers, extractors and vessels.

Case Histories

Figures 1 through 7 show the effects of this type of corrosion on gasketed joints. Figure 1 shows this corrosion in the fairly early stage before it had progressed to the point of replacement of the joint. The presence of isolated pits on the gasket bearing surface can be noted extending some distance into the surface away from the process liquid handled. The machined surface on the gasket face can be seen. This joint is properly designed and the corrosion encountered is the result of using an improper gasket material.

Figure 1—Type 316 stainless steel, 2-inch, 150-pound lap joint flange. Rubber asbestos composition gasket. Medium, 40% acetic acid, 5% low boilers, 1.5% formic acid, trace oxygen and peroxides, remainder water. Temperature 120 degrees F.

Figure 2 shows gasket surface attack when it has progressed beyond that apparent in Figure 1. The

E. V. KUNKEL—Maintenance Engineering Group Leader at Celanese Corporation of America's Bishop, Texas, plant. His inspection and corrosion control work began when he was transferred to the company's plant engineering department in 1946 after a year in the production department. A 1942 graduate of University of Texas in chemical engineering, he first worked for Gates Rubber Company in Denver. He joined Celanese in 1945.

Abstract

Examples of corrosion of austenitic stainless steel joint surfaces attacked by liquid media penetrating gaskets are described. The author postulates liquids of high electrical conductivity containing weak oxidizing and reducing agents are principally responsible for the pitting attack of the gasket bearing surfaces. Presence of chloride salts or organic chlorides in the gasketing material may contribute to stress corrosion cracking of the joint surface. Graphite seems to have no major influence although in some cases it may tend to aggravate the attack.

Corrosion is attributed to pools of liquid wicked through the gasket via fibers, as in gaskets with asbestos fiber fillers. Wicking by short fiber fillers is less than by long fibers. The small pools of liquid create active-passive and/or oxygen concentration cells with the entire inside surface of equipment as cathodic areas. This imbalance tends to accelerate pitting.

Control is achieved by using gasket materials without wicking constituents or which have continuous exterior surfaces of non-wicking material. Alteration of the process chemicals and application of a barrier coating between the gasket and the bearing surface of the joint were considered as control measures but not tested. Tests using 37 gasket materials compressed in racks suspended in the process stream showed non-fibrous materials to be superior.

Correct joint design is essential to reduce crevices which permit process liquid to seep between the gasket and the bearing surface. The author recommends that all mating surfaces be machined, that design prevent bolt-load from deforming gasket surfaces and that built-up stainless steel mating surfaces on carbon steel joints be avoided. Examples of correct and incorrect joints are shown. Testing gasket materials before use is recommended.

★A paper presented under the title "Gasket Surface Corrosion" at a meeting of South Central Region National Association of Corrosion Engineers, Tulsa, Okla., October 7-9, 1953.

Figure 2—Type 316 stainless steel, 2-inch, 150-pound fabricated stub end. Rubber asbestos composition gasket. Medium, 0.4% acetic acid, 1.5% formic acid, trace oxygen, remainder water. Temperature 235 degrees F.

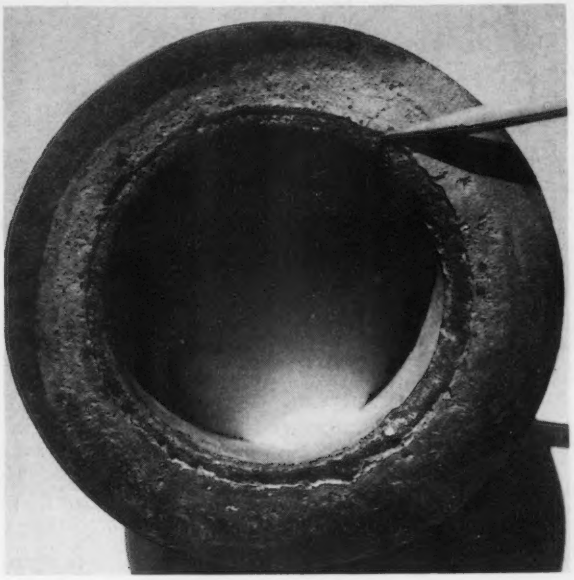


Figure 3—Type 316 stainless steel, 4-inch 150-pound fabricated stub end. Rubber asbestos composition gasket. Medium, 40% acetic acid, 5% low boilers, 1% formic, trace oxygen and peroxides, remainder water. Temperature 242 degrees F.

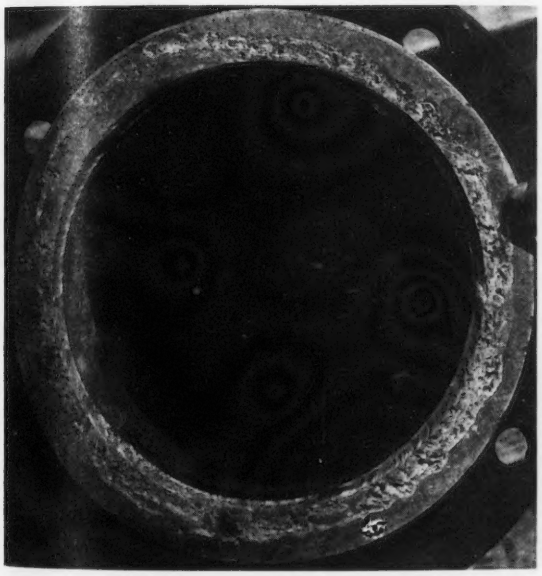


Figure 4—Type 316 stainless steel, 8-inch, lap joint flange. Rubber asbestos composition gasket. Medium, 10% formaldehyde, 0.05% formic acid, trace oxygen, remainder water. Temperature 280 degrees F.

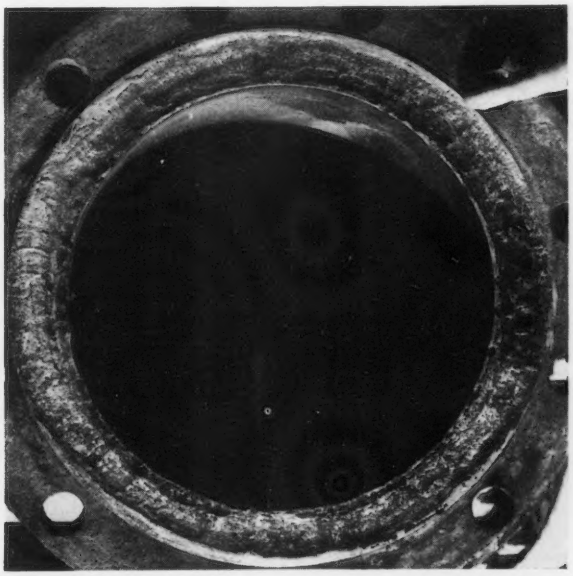


Figure 5—Type 304 stainless steel, 12-inch flange made of weld metal built up on carbon steel backing flange. Rubber asbestos composition gasket. Medium, 18% formaldehyde, 0.10% formic acid, 4-5 ppm oxygen, remainder water, pH 3.2 to 4.0. Temperature 290-300 degrees F.

absence of a machined gasket surface here is obvious and this poor joint design coupled with improper gasket selection are responsible for this deterioration.

Figure 3 shows heavy attack on the gasket surface. This is in the advanced stages of attack and it will be noted that the pits and general corrosion extend inward into the gasket surface some distance.

Figure 4 shows a rather advanced stage of deterioration in the form of elongated pits along with some general attack.

Figure 5 shows a 12-inch flange on a heat exchanger. Notice that the corrosion has progressed to the point of essentially complete removal of the gasket bearing surface. This gasket surface was prepared by building up stainless steel weld metal on a carbon steel backing flange. Although the gasket surface was machined, experience has shown that in general the building up of gasket surfaces with weld metal is not desirable when gasket surface corrosion is possible.

Figure 6—Type 304 stainless steel, 24-inch flange made of weld metal built up on carbon steel backing flange. Rubber asbestos composition sheet. Medium, 10% formaldehyde, 0.05% formic acid, trace oxygen, remainder water. Temperature 245 degrees F.

Figure 6 shows advanced stages of deterioration. This is a gasket bearing on a channel head of a Type 316 stainless steel heat exchanger. Here again the gasket surface was made by building up weld metal on a carbon steel backing flange.

Figure 7 shows the effect of gasket surface corrosion on a structural member from the inside of a fractionating tower. This member was ⅛-inch thick Type 316 stainless steel and the corrosion occurred within a six months' period. Note complete penetration of the member in some areas and essentially no corrosion at others. All of these items of equipment were exposed to aqueous corrosive media. Temperatures of exposure varied from room temperature up to 300 degrees F.

Corrosive Media Involved

Gasket bearing surface corrosion is encountered normally in austenitic stainless steel under conditions which have a tendency to give a pitting type of attack and/or set up active corrosion cells. In general, the liquid being handled is of high electrical conductivity and contains weak oxidizing and reducing agents co-existing in the process media. In most cases of excessive attack, the solution handled has been of this type. However, it is possible to have this type of attack under other conditions, such as those tending to produce general corrosion, but under these conditions the extent of the attack is generally reduced.

Other factors, such as the presence of chlorides, or other materials capable of breaking down the passive film, have a definite effect in this type of corrosion.

Table 1 shows typical corrosive media handled when this type of attack is encountered. The presence of objectionable materials compounded into the gasket is important in initiating deterioration. Chloride salts or organic chlorides may have a marked effect on producing stress corrosion cracking of the gasket surface. Any other acid forming group may be capable of reacting to break down the passive film on the gasket bearing surface. The effect of graphite on the gasket bearing surface is problematical. Numerous occasions have been seen where graphited surfaces were not appreciably deteriorated. In some cases the graphite may tend to aggravate the attack. However, it is felt that its role

Figure 7—Reinforcing member, Type 316 stainless steel, ⅛-inch original thickness. Rubber asbestos composition sheet. Medium, 10% formaldehyde, 0.1% formic acid, 5-10 ppm oxygen, remainder water, pH 3.5 to 4.2. Temperature 285 degrees F.

is secondary compared to other causes of the deterioration.

Theory

The use of asbestos sheets for gasketing in conventional joints generally results in exposure of asbestos fibers to the gasket bearing surface and to the process liquid being handled. Figure 8 illustrates how the process liquid may follow the asbestos fibers in the gasket material to form essentially stagnant pools of liquid on the gasket surface at points where the asbestos comes in contact with the surface. In this case, the asbestos fibers may act as wicks or passageways to allow the formation of pools of stagnant liquid at isolated points on the surface.

If one assumes that the process liquid is aerated it is very easy to see how an active-passive and/or oxygen concentration cell can be set up, especially if conditions are such that the corrosion rate is controlled by oxygen depolarization of the cathode areas. In this case, the stagnant pools of liquid entrapped in the gasket surface act as anode areas and the entire inside surface of the pieces of equipment, be it an exchanger, tower, vessel or piping, is capable of acting as a cathode area. In aerated solutions, oxygen, if present, may act in its role as a cathode depolarizer.

TABLE 1

Typical Media Found to Cause Gasket Bearing Surface Corrosion

Example 1:

Formaldehyde	10%
Formic Acid	0.1%
O_2	5-10 ppm
Water	Remainder
pH	3.5 to 4.2
Temperature—285° F	
Agitation—Rapid	

Example 2:

Formaldehyde	18%
Formic Acid	0.1%
Glycols	1. %
O_2	4-5 ppm
Water	Remainder
pH	3.2 to 4.0
Temperature—300° F	
Agitation—Rapid	

Example 3:

Acetic Acid	40%
Formic Acid	0.8%
Acetaldehyde	5%
Peracetic Acid	Trace
Water	Remainder

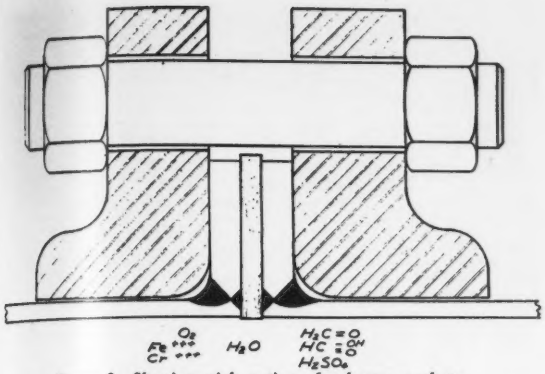


Figure 8—Showing wick action of asbestos gaskets.

With this unfavorable area relationship of anode to cathode areas, it is apparent how this attack can progress at a very rapid rate once the corrosion action has been established. Other factors, such as ion concentration cells and differentials in pH's between the points of stagnant liquid in the gasket surface and the moving liquid inside the equipment may give an additive effect to stimulate and increase the rate of attack.

Methods of Prevention

In consideration of this theory, several methods of attack are apparent which could be used to control this type of deterioration. The first method and the method on which tests reported herein are based, is to place a physical barrier between the gasket surface and the process liquid to prevent formation of the pools of stagnant liquid on the bearing surface. The value of this method of prevention is demonstrated in the test results presented.

The second method which may be used is a control of the process stream to reduce the general corrosivity of the stream. Methods such as pH control and removal of depolarizing agents have proved their value in actual operations.

The use of cathodic inhibitors to blanket the cathode areas was not explored in this work but appears to have considerable merit.

The third method of control may be to use a specially prepared gasket dope to keep the entire gasket surface essentially in the cathodic condition. This possibility was not explored. However, it may be of definite advantage, especially if the dope use acts also as a physical barrier between the asbestos fibers and the gasket surface to prevent formation of liquid pools.

Test Method

The test method used was to compress small samples of gasket materials between mating surfaces of Type 316 stainless steel and to expose them in racks inside of towers and heat exchangers under operating conditions. All surfaces were ground with 120-grit paper prior to assembly of racks. Two types of gasket test racks were used. Figure 9 shows the type originally used. These racks were 12 x 4 x ⅛-inch Type 316 stainless steel plate with gasket retaining plates 1 x 3 x ¼-inch. Duplicate gasket specimens

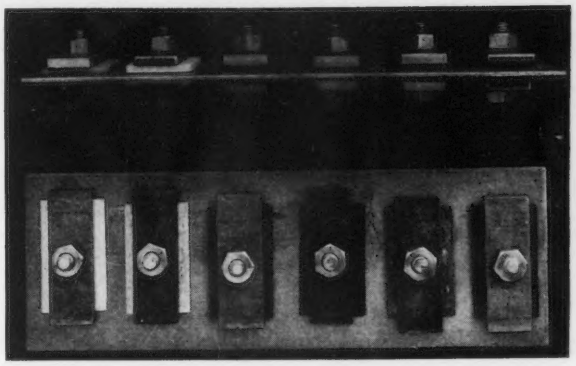


Figure 9—First test rack used.

Figure 10—Improved test rack.

were cut to 2½ x 1½-inch in order to allow the retaining plates to extend ¼-inch over each end of the gasket material and to allow the gasket material to extend ¼-inch beyond the retaining plates on the sides. Three-eighths-inch diameter Type 316 stainless steel bolts were used to assemble these racks and to compress the gasket material between the retain-

TABLE 2
Media to Which Test Racks Were Exposed

Example 1:

Formaldehyde	0.2%
Other Mixed Aldehydes (C_2, C_3 etc.)	8.2%
Mixed Alcohols (C, C_2, C_3 etc.)	6.0%
Mixed Acetates & Formates (C, C_2 C_3, etc.)	0.25%
Ketones (C_3, C_4 etc.)	0.70%
Formic Acid	0.03%
Water	Remainder

pH—5-6
Aeration—Slight
Agitation—Rapid
Temperature—230° F

Example 2:

Acetic Acid	0.4%
Formic Acid	1.65%
Water	Remainder

Aeration—Slight
Agitation—Rapid
Temperature—230°-240° F

Example 3:

Acetic Acid	40%
Formic Acid	1.5%
Water	Remainder

Aeration—Yes
Agitation—Rapid
Temperature—265°-280° F

TABLE 3

General Class Gasket Material	No. of Each Type Tested
Rubber Asbestos Comp. Sheets	6
Neoprene Asbestos Comp. Sheets	9
Hycar Asbestos Comp. Sheets	4
Rubber (No Asbestos)	2
Neoprene (No Asbestos)	5
Hycar (No Asbestos)	4
Silicone (No Asbestos)	2
Butyl Rubber (No Asbestos)	1
Teflon (No Asbestos)	1
Unknown sheets	3

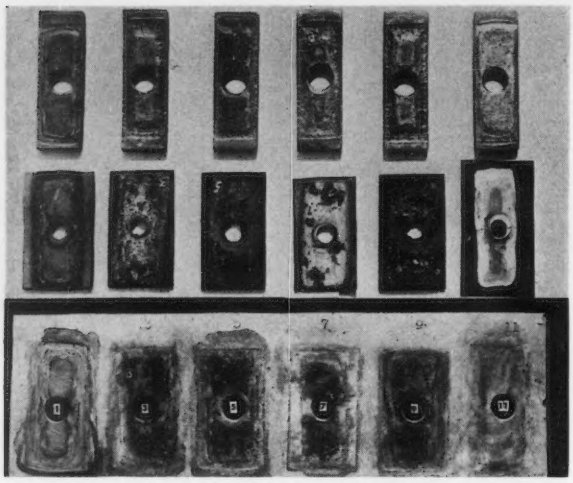


Figure 11—Disassembled test rack after exposure in Medium Example 1 in Table 2. Specimens were as numbered: 1—Red rubber. 3—Rubber, asbestos compound No. 3. 5—Rubber asbestos compound No. 2. 7—Rubber asbestos compound No. 1. 9—Neoprene asbestos compound. 11—Silicone rubber.

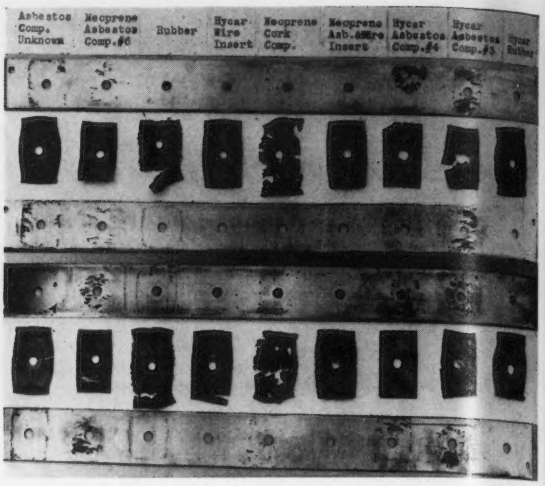


Figure 12—This test rack was exposed in Medium Example 2 described in Table 2.

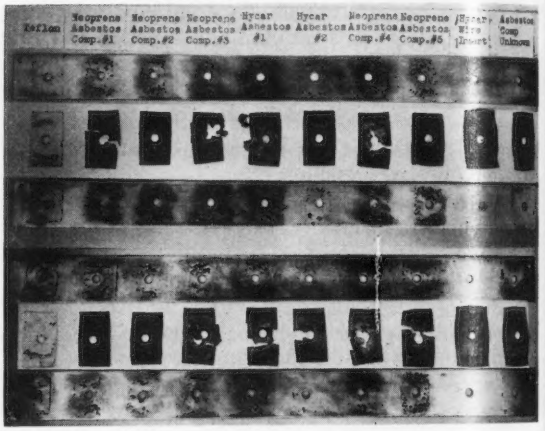


Figure 13—This test rack was exposed in Medium Example 2 described in Table 2.

ing plates and the test plate. Hand wrenches were used to tighten the bolts until visual yielding of the material was noted. Some trouble was encountered with this rack as a result of bolt failures and later a different rack was used as shown in Figure 10. It is essentially the same type of rack but of somewhat different construction. Here the gasket materials again are compressed between plates of Type 316 stainless steel and pressure was applied on the ⅜-inch diameter bolts in the same manner as the unsatisfactory rack. Complete loss of specimens was eliminated even though one or two bolts might fail prior to removal of the rack. Eleven racks of the original design and four racks of the modified design were used.

Test racks were installed in service where past experience had indicated the occurrence of maximum gasket surface corrosion. All streams in which tests were conducted were of the type which contained both weak oxidizing and reducing agents co-existing in the solution. Exposure temperatures ranged from 230 to 280 degrees F. Table 2 shows typical media in which tests were run.

Thirty-seven different gasket materials comprising 202 separate specimens were tested on 15 racks. The different types of gasket materials are shown in Table 3. These gasket materials are roughly classified as to general types and no information was available relative to the exact composition of the binders used or in some cases of the grade of asbestos used. Considerably more basic information could have been evolved if the exact composition of all of the sheets tested could have been obtained. None of the materials tested were graphited because general practice is to not use graphited sheets in gasketing stainless steel equipment.

Evaluation of the test racks was made by removing the bolt attachments after exposure, separating and cleaning the surfaces and evaluating by measurement and visual examination. Evaluation was made on the basis of estimating the percent of area pitted, by measuring the actual depths of the pits and by noting the condition of gasket material upon removal and its ease of removal from the bearing surface proper. These factors all were taken into consideration in giving each material a rating. Figures 11, 12 and 13 are typical of conditions encountered upon removal and evaluation of racks.

Results and Conclusions

Rubber-asbestos composition sheets produce the most severe corrosion. Both the Neoprene and Hycar asbestos composition sheets produced considerably less gasket bearing surface corrosion than the rubber-asbestos composition sheets. There appeared to be very little difference between the Neoprene and Hycar asbestos composition sheets. In all cases non-asbestos containing materials caused virtually no bearing surface corrosion.

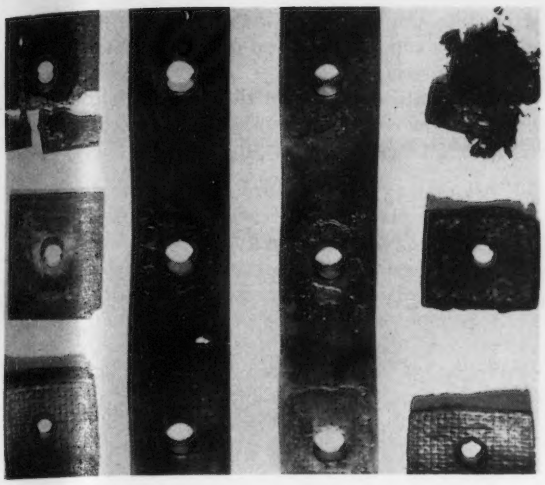


Figure 14—This test rack was exposed in Medium Example 2 described in Table 2.

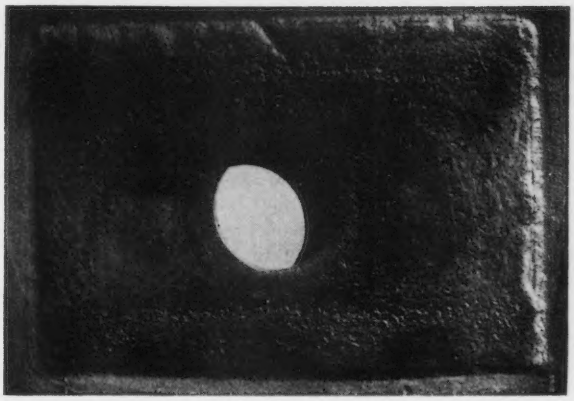
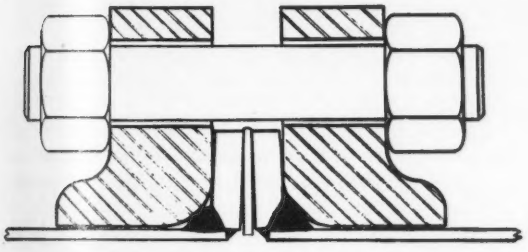
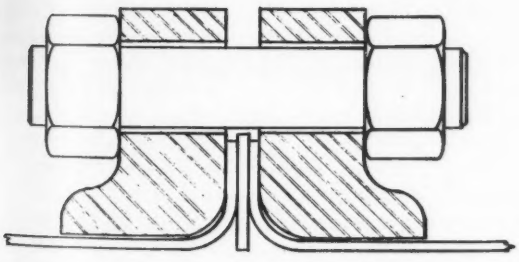


Figure 15—This specimen was exposed in Medium Example 3 described in Table 2.

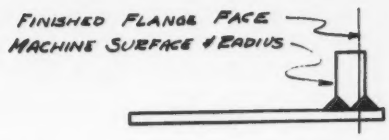


FABRICATED - NOT MACHINED

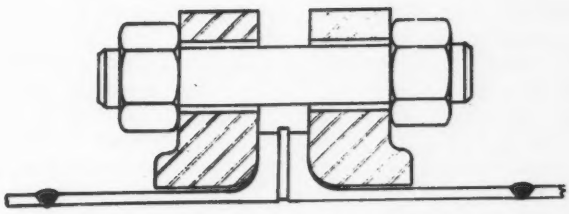


ROLLED FLANGE - NOT MACHINED

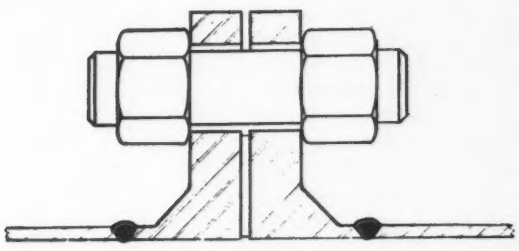
Figure 16



FABRICATION OF LAP JOINT STUB END



LAP JOINT FLANGE



BUTT-WELD FLANGE

Figure 17

Non-Fibrous Materials Superior

Gasket materials which contain no asbestos or fibrous materials dispersed in them are far superior in preventing gasket surface corrosion to those which contain these materials. Also non-fibrous materials which contain asbestos but present a Hycar, Neoprene, rubber, or other continuous non-fibrous surface in contact with the gasket bearing are like those containing no fiber whatsoever.

Of the asbestos composition sheets, those with high binder-to-asbestos ratios appear superior to those with low binder-to-asbestos ratios. This is due to the fact that fewer points of contact between asbestos fibers and the gasket bearing surface are available. Gasket materials which contain short staple asbestos intimately dispersed in the binder showed less attack than those with long staple asbestos filler. This probably is due to the fact that the short staple fiber provides fewer channels for process liquid to follow and thereby form liquid pools on the bearing surface.

There appears to be very little difference between the different binders tested, that is between the sulfur curing compounds (Hycar and rubber) and those

which are not (Neoprene). The oil and solvent resistant types (Hycar and Neoprene) in general show an advantage over the non-resistant type (rubber). Several cases were noted in the test where stress corrosion cracking was encountered in Neoprene asbestos composition sheets, but determination was not made of items compounded in the sheet which may be responsible for this corrosion. It has been assumed that it is probably due to the presence of a chloride salt or an organic chloride plasticizing agent. Only two of the nine Neoprene asbestos composition sheets tested showed stress corrosion cracking.

Stress-Corrosion Cracking

Figures 14 and 15 show stress corrosion cracking in the gasket bearing surface. This type of attack is probably the result of chloride-containing materials in the gasket sheet.

Lack of other properties of good gasket material, such as yield strength, solvent resistance, resilience and hardening and the like, make some materials tested impractical for general use.

Tests reported here show the need to carefully select gasket material to prevent gasket surface corrosion.

Of equal importance in a practical system is the actual joint design. A properly designed joint is especially important because the process liquid must be barred from the gasket bearing surface is corrosion is to be prevented. Poorly constructed lap joint or van stone flanges may contribute materially to this type of attack. Figure 16 (top) illustrates a fabricated lap joint flange which was not machined prior to installation. Note the crevices which allow process liquid to come in contact with the gasket bearing surface and thereby initiate corrosion. The lower half of this figure illustrates a typical rolled flange. Crevices here, both as a result of the nature of the flange and its lack of machining again may result in accelerated attack. Figure 17 illustrates joints properly designed to eliminate as much as possible this type of corrosion resulting from poor flange design. The top portion of this figure shows a section of fabricated lap joint stud end indicating surfaces to be machined prior to use. The center part shows a fabricated stub end of this type or a purchased machined stub end after installation. Notice specifically that the stainless steel welded portion of these stub ends is rather thick as compared to the cross section thickness of the pipe. This tends to prevent the gasket surface cupping excessively when the bolt load is applied to compress the gasket material. The lowest portion of Figure 17 shows a conventional butt weld flange which is considered of good design. Notice in both cases the machined metal surfaces which allow relatively even compression of the gasket material as bolt pressure is applied.

In summation of gasket design, the following factors have proved to be valuable in controlling corrosion of gasket surfaces:

1. All mating surfaces are to be machined so that parallel planes are present in the gasket bearing surface. Non-machined joints should never be considered for use in corrosion service.
2. The joints should be so designed that the bolt load does not deform or cup the mating gasket surfaces excessively.
3. Building up stainless steel gasket surfaces on carbon steel flanges by laying in weld beads should be avoided as much as possible. Experience has shown that excessive deterioration of the gasket bearing surface generally is encountered with this type of construction. (Figures 5 and 6 show gasket surfaces constructed in this manner.)

In most services, properly designed lap joint flanges or weld neck flanges are practical and will give good service within their pressure rating if proper care is taken.

The use of other type joints, such as tongue and groove, large and small male and female joints and ring joints were not included in this study. However, it can be expected that the same principles regarding crevices will apply to these joints as much as to the flat face joints.

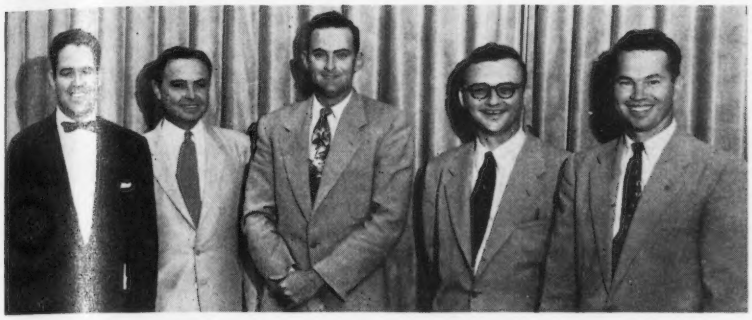
Summary

Gasket bearing surface corrosion may be controlled by proper selection of gasket material, by proper joint design and by modification of corrosion characteristics of the process fluid being handled. Economics of control of this type of corrosion is an essential consideration in determining what type of combination of control is to be used. Economics are generally such that proper selection of gasket material and proper joint design are essential. The advisability of modifying corrosion characteristics of process fluid must be determined on an economic basis for each fluid handled. Gasket materials can be safely selected only after testing, either with test panel and/or with actual joints in operating equipment.

The author acknowledges his indebtedness to R. C. Schueler and to J. A. Manning for their assistance and consultation and their assembly and installation of test racks; and to C. C. Weikal for his photographic assistance.

NACE News

Six Symposia Scheduled for Dallas Meeting



EAST TENNESSEE SECTION'S first meeting June 17 had Clyde Watson (left), Oak Ridge National Laboratory, as technical speaker. Others pictured, left to right, are E. P. Tait, Alloy Steel Products Co., Atlanta, regional director; Charles F. Fisher, Jr., Knoxville section, vice-chairman; James L. English, Oak Ridge, secretary-treasurer, and Anton deS. Brasunas, University of Tennessee, section chairman.

Emphasis Placed on Coatings, Inhibitors In Oil Industry

Six symposia of technical papers and two discussion programs have been scheduled for the October 14-15 meeting in Dallas of South Central Region, National Association of Corrosion Engineers. Symposia will be presented on cathodic protection, protective coatings, inhibitors, processing plant corrosion problems, pipe line corrosion, and oil and gas production. Discussion programs will consist of a question and answer audience participation session and a general round table on oil and gas transportation.

R. C. Buchan, Humble Oil and Refining Co., Houston is technical program chairman. H. L. Bilhartz, Atlantic Refining Co., Dallas is general chairman.

Scheduled symposia, titles of papers and authors are as follows:

Cathodic Protection Symposium

Thursday morning, October 14. Tom R. Statham, Magnolia Pipe Line Co., Dallas, chairman.

Current Requirements for Cathodic Protection of Pipe Lines by Marshall E. Parker, Consulting Engineers, Houston.

Selection of Galvanic Anodes or Rectifiers for Cathodic Protection of City Distribution Systems by Charles L. Woody, United Gas Corp., Houston.

Cathodic Protection Applied to a Large Diameter Oil Pipe Line System by D. O. Griffith, Shell Pipe Line Corporation, Houston.

Protective Coating Symposium

Thursday afternoon, October 14, L. G. Sharpe, Napko Paint & Varnish Works, Houston, chairman.

There Ain't No Mystery in Paint by J. E. Rench, Napko Paint & Varnish Works, Houston.

(Continued on Page 2)

Western Region's Fourth Annual Conference, UCLA Short Course Scheduled Nov. 15-19

A full week of corrosion activities has been scheduled at Los Angeles November 15-19 by Western Region NACE. There will be an NACE-sponsored 3-day short course on corrosion at University of California at Los Angeles November 15-17 and a two-day Fourth Annual Conference of Western Region November 18-19. The short course will be on the UCLA campus and the conference at the Biltmore Hotel.

The short course, on protective coatings, will consist of sessions on theory, surface preparation, application, and testing, evaluation and drawing of specifications.

The technical program for the conference has scheduled tentatively a six-hour session on marine corrosion with W. L. Whiteneck, Long Beach Harbor Dept., Long Beach as chairman; a four-hour session on waste disposal, both sewage and oil production waste, to have C. G. Munger, Amercoat Corp., South Gate as chairman and a round table discussion of about four hours on corrosion of steel pipe.

Scott P. Ewing, Carter Oil Co., Tulsa is being sought as keynote speaker at the banquet scheduled November 18. Registration is $5. J. G. Kerr, C. F. Braun Co., 1000 S. Fremont Ave., Alhambra, Cal., is registration chairman.

Committees planning the Fourth Annual Conference Program will be as follows:

Program Committee—Chairman: H. J. Keeling; Co-chairmen: C. G. Munger, L. L. Whiteneck, N. K. Senatoroff.

Publicity Committee—Chairman: W. F. McNaughton.

Facilities-Arrangements Committee—Chairman: J. W. Coffey; Co-chairman: J. S. Dorsey.

Education Committee—Chairman: N. K. Senatoroff; Co-chairman: R. R. Ashline.

Membership Committee—Chairman: A. G. Zima; Co-chairman: R. W. McIntosh.

Registration Committee—Chairman: J. G. Kerr; Co-chairman: R. W. Marshall.

Hospitality Committee—Chairman: R. J. Ronan.

Rocky Mountain Section

The second meeting of the Rocky Mountain Section was held May 14 at the Olin Hotel in Denver, Colorado with 42 members and guests present. Jay R. James, Cathodic Protection Service Company spoke on the subject of Corrosion Fundamentals and Practical Applications of Cathodic Protection, which was followed by numerous questions.

Next regularly scheduled meeting of the section is September 17.

HALF-YEAR MEMBERSHIPS IN NACE

Applications for active membership in the National Association of Corrosion Engineers received at the Central Office after July 1st, may, at the option of the applicant, be for the last half of the calendar year—July-December inclusive, with dues of $5.00.

- **This half-year membership entitles the member to receive copies of CORROSION magazine for the months of July-December, inclusive and all the benefits of the association after July 1.**
- **If you are interested in membership in NACE write for an application for membership or see the NACE Section secretary if an NACE section operates in your city.**
- **Applications for membership for the whole of the calendar year will be accepted also and copies of CORROSION supplied for the whole year as long as the supply of back issues lasts.**

Write to A. B. Campbell, Executive Secretary NATIONAL ASSOCIATION OF CORROSION ENGINEERS, 1061 M & M Bldg., Houston 2, Texas.

Alamo Section Petition Has Been Submitted

E. A. TICE, shown seated at the table, was leader of a panel discussion on corrosion during the 65th Annual Convention of the Heating, Piping and Air Conditioning Contractors' National Association May 25-28 at Atlantic City. The two-hour session was well attended. Mr. Tice's services for the discussion were secured through Northeast Region, NACE.

Southwestern Ohio Holds Meeting at Cincinnati

Southwestern Ohio Section held its sixth meeting of the 1953-1954 season May 25 at Shullers Restaurant, Cincinnati. Reports of two technical committees were presented by Mr. Falck on Protective Coatings and Mr. Lineback on Electrolysis and Corrosion.

R. L. Featherly of Dow Chemical Company spoke on Cathodic Protection and discussed many interesting practical aspects of the field, his talk being followed by a general question and answer period. Thirty-one members and guests were present for the dinner at which Walter Luce was installed as chairman for the 1954-1955 season.

Holmberg Talks at May 19 San Francisco Meeting

E. G. Holmberg, Alloy Steel Products Company, spoke on Corrosion as Influenced by Design and Alloy Composition at the May 19 meeting of the San Francisco Bay Area. Mr. Holmberg discussed the importance of knowledge of the basic principles of corrosion in designing equipment for corrosive service.

With the aid of slides a number of common errors in design were demonstrated. Data were also presented on field exposure of various alloys to sulfuric acid sludge, acetic acid and other aqueous environments. The data were arranged to point out the effects of small changes in alloy composition on the resistance of the alloy to corrosion.

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Mooring cables on TVA floating booms at Paducah are now protected by neoprene jackets to prevent corrosion fatigue. Original cables cost $10,000 and failed in 5 years.

The newly formed Alamo Section of the National Association of Corrosion Engineers has submitted its petition for recognition to the South Central Region Division Board of Trustees for approval. A copy of the rules and regulations of the Alamo Section has been presented also to the board for approval.

W. W. Elley, Southwestern Bell Telephone Company, San Antonio, Texas was elected temporary chairman and C. W. Tipps, City Public Service Board, San Antonio was elected temporary secretary.

Vancouver Section Hears Teeple at June 11 Meeting

H. O. Teeple of the International Nickel Company, Inc., New York, spoke on Corrosion and Corrosion Engineers at the June 11 meeting of the Vancouver Section. Mr. Teeple's talk was well received by the 26 members and guests present.

Plans for a corrosion short course to be held at the University of British Columbia in November were announced by R. J. Law, Canadian Regional Director.

Color Slides, Movies Shown at Corpus Christi

Lester Brusse of the Industrial Waterproofing Company showed 3-D color slides of the shallow waters in the bays and inlets of the gulf coastal bend area at the June 22 meeting of the Corpus Christi Section. Also shown were aerial slides in and near Corpus Christi, showing the highly concentrated industrial area, which accounts for heavy product as well as atmospheric corrosion. Two short movies showing the use of properly formulated mastic coatings also were a feature of the meeting.

The program presented by Mr. Brusse was well received.

Six Symposia—

(Continued from Page 1)

Technique of Application as Related to Vinyl Protective Coatings, by Loyd Brudvig, Corrosion Service Company, Odessa and T. B. Burris, Plastic Coating Corp., Houston.

Internal Plastic Coating of Pipelines in Place by J. C. Watts, Humble Pipe Line Company, Midland.

Inhibitor Symposium—I

H. E. Waldrip, Gulf Oil Corp., Houston, chairman; W. F. Oxford, Jr., Sun Oil Company, Beaumont, co-chairman.

Use of the Pearson Bridge in Corrosion Inhibitor Evaluation by E. J. Simmons, Sun Oil Co., Dallas.

Laboratory Development of Corrosion Inhibitors by J. P. Barrett, Stanolind Oil and Gas Co., Tulsa.

Laboratory Studies of the Minimum Concentration and Durability of Oil Well Corrosion Inhibitors by F. P. Steinhauff, Humble Oil & Refining Co., Houston.

Inhibitor Symposium—II

Thursday afternoon, October 14, H. E. Waldrip, Gulf Oil Corp., Houston, chairman; W. F. Oxford, Jr., Sun Oil Co., Beaumont, co-chairman.

Acid Corrosion Inhibition by High Molecular Weight Nitrogen-Containing Compounds, by Raymond A. George and Norman Hackerman, The University of Texas, Austin.

Development of Standardized Laboratory Methods for Screening Corrosion Inhibitors for Use in Oil and Gas Wells, by E. C. Greco, United Gas Pipe Line Company, Shreveport and J. C. Spaulding, Jr., Sun Oil Co., Dallas.

Correlation of the Results Obtained with Corrosion Inhibitors in the Laboratory and in the Field by G. E. Purdy, Tretolite Co., St. Louis.

Processing Plants Symposium

Friday morning, October 15, Herbert E. Morris, Monsanto Chemical Company, Texas City, chairman.

Selection of Materials from Some Petroleum Refinery Applications by J. F. Mason, Jr., The International Nickel Co., Inc., New York.

The Question Box

Friday morning, October 15—Audience participation question-and-answer forum.

Pipe Line Corrosion Symposium

Friday morning, October 15, Lyle R. Sheppard, Shell Pipe Line Corp., Houston, chairman.

Conductance of Pipe Line Coatings by L. F. Heverly, Heverly Engineering Co., Kansas City, Kansas.

Function and Aims of T-2 by W. H. Stewart, Sun Pipe Line Company, Beaumont, Texas.

Control of Internal Corrosion of a Products Pipe Line System by P. L. DeVerter, Humble Oil & Refining Company, Baytown, Texas, and A. W. Jasek, Humble Pipe Line Company, Houston, Texas.

Oil and Gas Production Symposium

Friday morning, October 15, E. C. Greco, United Gas Corp., Shreveport, La., chairman.

Evaluation of Corrosion in Gas Plants by B. W. Bradley, Shell Oil Co., New York, N. Y.

Microbiology in the Petroleum Industry by D. M. Updegraff, Magnolia Petroleum Co., Dallas, Texas.

Corrosion of Oil Well Casing by Earth Currents by L. deWitte and F. J. Radd, Continental Oil Co., Ponca City, Okla.

Use of Potential Profiles to Evaluate Current Requirements for Control of Casing Corrosion by J. D. Sudbury, J. E. Landers and D. A. Shock, Continental Oil Co., Ponca City, Okla.

Use of Ammonia to Prevent Casing Corrosion by H. E. Greenwell, Rado Loncaric and H. Byars, Atlantic Refining Co., Dallas.

Oil and Gas Transportation Symposium

Friday afternoon, October 15, J. N. Hunter, Jr., Service Pipe Line Company, Tulsa, Okla., chairman. General round table.

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Bacteria reduced solids content of effluent from a pharmaceutical plant from 500,000 ppm to a manageable volume.

Corrosion of Centrifugal Pumps is Discussed

Centrifugal Pump Corrosion—Causes and Prevention, an illustrated discussion by F. R. Drahos, chief metallurgist for the Byron Jackson Company was the topic at the June 16 meeting of San Diego Section at Vista, Cal. Mr. Drahos talked about corrosion of pumps and enumerated the preferred materials for pumps used in mining, power plant, industrial, agricultural, chemical and petroleum applications. A lively question and answer session followed.

The meeting, attended by 49 members and several guests was considered by many to have been the most successful of the year.

Talk on Valve Engineering Heard by Detroit Section

Materials Engineering of Valves for Corrosion Services was the subject of R. McFarland, Hills-McCanna Company, at the May 27 meeting of the Detroit Section. The talk was illustrated and emphasis placed on deliberate technical selection of the proper materials for each specific application. All plastics were viewed as liquids and the physical changes the plastics undergo due to diluents or contaminants were considered.

R. G. Roberts

R. G. Roberts, 63, technical engineer of Barrett Division, Allied Chemical & Dye Corp., Chicago, died June 16 at his home in Chicago. He joined Barrett 33 years ago and was considered an authority on pipeline construction and in particular on protective coatings. His membership in the National Association of Corrosion Engineers is numbered 119 and is dated March 2, 1944.

Baltimore Section

Luther O. Young of The Davison Chemical Corporation, Baltimore, has been elected secretary-treasurer of the Baltimore Section to fill the unexpired term of Adolph Bialecki, who was transferred from the Baltimore area earlier in the year.

SHORT COURSE CALENDAR

1954

Nov. 15-17, UCLA, Los Angeles, California; Protective Coatings

November, University of British Columbia, Vancouver, British Columbia, Canada

1955

Jan. or Feb., UCLA, Los Angeles, Cal.

Feb. 2-4—University of Toronto, Hart House Theater, Toronto.

Feb. 16-18—Tulsa Section, Sixth Annual Short Course. Mayo Hotel, Tulsa, Okla.

Fall—Washington University, St. Louis, Missouri.

East Tennessee Section Holds First Meeting

The newly formed NACE East Tennessee Section held its first meeting on June 17 in Knoxville, Tenn. Clyde Watson of the Oak Ridge National Laboratory spoke on protective coatings, emphasizing the need for metal protection from corrosion, the desire for pleasing appearances and discussing coatings of various types. He indicated a minimum of three coats is necessary for optimum protection against pinholes and a thickness of six mils desirable for protection. The need for cleaning, especially in atomic energy installations where contaminants must be carefully removed prior to coating also was pointed out to be vital.

During the business session, E. P. Tait, director of the NACE Southeast Region, presented the section charter to Anton deS Brasunas, first chairman of the section. Charles F. Fisher, Jr. of the East Tennessee Natural Gas Company, was elected vice-chairman and James English of the Oak Ridge National Laboratory was elected secretary-treasurer.

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Ultraviolet radiation, humidity, rain and dust erosion and temperature contribute most to degradation of styrene and phenolic plastic materials, according to J. R. Taylor and C. H. Adams, Monsanto Chemical Co., Springfield, Mass., in their AIChE paper "Weather Aging of Styrene and Phenolic Plastics."

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NATIONAL ASSOCIATION OF CORROSION ENGINEERS

Technical Committee News

Final Solutions for Nitric Acid Corrosion Sought

Poor Selection of Materials Cited as Weak Link by Utilities

In its work on the selection of materials for corrosion mitigation, Unit Committee T-4F on Materials Selection for Corrosion Mitigation in the Utility Industry has pointed to a weak link in the chain of corrosion resistant materials used in water works installations. The picture on the cover of the August 1954 issue of Corrosion shows what happens to a babbitt bearing used with a bronze shaft on a 24-inch check valve. David Hendrickson, of the East Bay Municipal Utility District, Oakland, California, chairman of the committee T-4F, says replacement of babbitt in the check valve may seem to be an insignificant matter. However, if the investment of over $22,000,000 in one aqueduct serving approximately 1,000,000 people is considered replacement becomes a major operation.

Capacity of these large aqueducts is about 1,000,000 gallons per mile and when about 100 miles of line has to be emptied before the valve can be repaired, several days shut down is required. While aqueducts are designed to last about 100 years, some fixtures in the line give trouble within 10 years. Mr. Hendrickson says much of this type of trouble can be avoided through selection of materials with the correct galvanic relationship when they are to be in contact with water or moisture. In the valve described here, proper selection of materials would have prevented the accelerated corrosion which caused the shutting down of the aqueduct.

Wainwright is New T2-C Vice-Chairman

Ray M. Wainwright, University of Illinois, Urbana has been elected vice-chairman of Unit Committee T-2C on Minimum Current Requirements for Cathodic Protection. He also is chairman of Unit Committee T-4A on Effects of Electrical Grounding on Corrosion and is chairman of the American Institute of Electrical Engineers' committee concerned with cathodic protection.

He is project supervisor on a corrosion research project sponsored by the Utilities Research Commission at the Electrical Engineering Research Laboratory, Engineering Experiment Station, University of Illinois. Progress reports on the research were reviewed in July Corrosion.

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Abstracts published in the NACE Abstract Punch Card Service come from more than 500 periodicals all over the world. Coding by topic, journal, author and year is provided.

TECHNICAL COMMITTEES INVITED TO MEET AT DALLAS OCTOBER 12-15

All NACE Technical Committees are invited to hold a meeting during the South Central Region meeting at Dallas October 12-15, 1954.

The meeting will be in the Adolphus Hotel, which has adequate meeting room facilities to accommodate as many committees as may wish to meet. Two days, October 12 and 13, have been reserved for committee meetings so that there will be no conflict with technical symposia scheduled October 14 and 15.

All committees are urged to take advantage of this opportunity to meet and attend the excellent technical program planned by South Central Region.

For further information or to schedule a meeting of your committee, write to T. J. Hull, NACE, 1061 M & M Building, Houston 2, Texas, or H. L. Bilhartz, Production Profits, Inc., 2406 North Fitzhugh Avenue, Dallas, Texas.

Sudrabin Is Elected Vice-Chairman of T-2

L. P. Sudrabin, Electro Rust-Proofing Corp., Newark, New Jersey, has been elected vice-chairman of T-2. Announcement of the results of the election for vice-chairman was made recently by W. H. Stewart, Sun Pipe Line Company, Beaumont, Texas, chairman of committee T-2.

Mr. Sudrabin long has been active in NACE technical committee work and is currently chairman of Unit committee T-2C on Minimum Current Requirements for Cathodic Protection. He is the author of the T-2 report on Some Observations of Cathodic Potential Criteria in Localized Pitting, published in the Technical Committee News Section of the August 1954 issue of Corrosion.

Mr. Sudrabin is a graduate of Northeastern University, with a BS in chemical engineering and is technical director of Electro Rust-Proofing Corp. Before becoming affiliated with the Electro Rust-Proofing Corp., he served as research engineer with the Door Company; chief chemical engineer with the Dayton Power & Light Company and chemist with the Boston Edison Company. He is the author of several papers on corrosion by water.

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Stainless steel inlet pipes were necessary for one pilot sewage treatment system at a chemical plant where effluent has a pH of 2 to 2½.

Questionnaire and Bibliography Planned By Committee T-5A-5

More than stop-gap temporary solutions are needed for serious corrosion problems in the production and use of nitric acid. Committee T-5A-5 on Corrosion by Nitric Acid has outlined some of the more serious problems the industry faces and plans to circulate a questionnaire to large scale users and producers to determine the specific type of corrosion control information needed. Results of this questionnaire will determine the extent and order of precedence of the committee's work.

The committee also has projected for 1954 preparation of a bibliography on nitric acid corrosion. While the plan is to ultimately make the bibliography sufficiently comprehensive to cover all phases of nitric acid corrosion, initially it will be limited to items of immediate interest to the committee.

An interim report on the committee's activity and progress also is in preparation.

Some of the major problems in the production of nitric acid to which the committee is now devoting considerable attention are described as follows:

1. Proper material selection to minimize tube corrosion in nitric acid reboilers. Corrosion attack has been observed to be considerably aggravated at temperatures approaching 200 degrees F. Information is needed to evaluate the relative merits between expanding tube ends vs. placing seal welds around the tube projections in the reboilers.
2. Type 347 stainless steel tube sheets and tubes for heat exchangers operating at 120 psi and within a temperature range between 1600 and 1700 degrees F have a life expectancy on the order of two years. A more suitable alloy is required. In some instances, refractory cement facings are now being used to coat metallic surfaces exposed to high operating temperatures.
3. Weld corrosion has been a particular problem in stainless steel storage tanks used to contain mixed acids (nitric and sulfuric). Operating experience has indicated a preference for manual rather than the automatic type of welds. Corrosion data on various types of automatic-weld filler rods are needed. After a stress relief treatment, the automatic-type of welds were found to be fairly satisfactory but not for tank car use. In the case of aluminum equipment, all welding techniques (including the heliarc method to some extent) result in severe corrosion attack at weldments where the equipment is

(Continued on Page 6)

T-4 Elects Dietze as New Vice-Chairman

Irwin C. Dietze, Dept. of Water & Power, Los Angeles, has been elected vice chairman of Group Committee T-4. Mr. Dietze is currently chairman of NACE Unit Committee T-4B on Corrosion of Cable Sheaths and has long been active in the affairs of NACE and its technical committees.

In addition to Mr. Dietze's work in technical committees, he served on NACE's board of directors, representing the Western Regional Division for three years.

F. E. Kulman, Consolidated Edison Co. of N. Y., Inc., New York, is the chairman of Group Committee T-4.

Final Solutions—

(Continued from Page 5)

in contact with concentrated nitric acid at boiling temperature.

4. Construction materials for Pauling towers frequently exhibit cracking through the flanges and wells at temperatures around 360 degrees F and when in contact with 68 percent sulfuric acid solutions containing small amounts of nitric acid. Careful design and installation of sections are mandatory to compensate for the lack of a more corrosion-resistant metal or alloy.
5. Titanium metal has exhibited very satisfactory performance for containing red fuming nitric acid and the related oxides of nitrogen at temperatures of 400 degrees F. Recently, however, reports on explosions with titanium (and its alloys) concentrated nitric acid systems have given rise to serious concern over the use of this combination. Careful study is most certainly needed along these lines.
6. Corrosion information is required to differentiate between the behavior of balanced and unbalanced alloy compositions in nitric acid of various concentrations. A corollary problem is the maximum ferrite concentration level that can be tolerated without impairing corrosion resistance.
7. Because of the high incidence of crater, micro, root, and base metal cracks in Type 347 stainless steel, information is needed on how to avoid the formation of such cracks. It is also necessary that fabricators and consumers have proper information regarding the necessary heat-treatment to avoid knife-line attack in welds prepared with Type 347 stainless steel for use in nitric acid service. Heat treatment of 347 stainless steel after welding is not generally practiced although the trend has been toward the use of a 1650 degree F anneal followed by a slow-cooling period.
8. Although the reason for selecting Type 430 stainless steel over Type 347 stainless steel is usually one of the economics, it has been found that most nitric acid plants employ a mixture of the two types for construction purposes. Type 347 stainless steel lends itself more readily for field maintenance welding. Field welding of Type 430 stainless steel is not as easy.
9. Corrosion data are needed to aid in the selection of Type 321 vs. Type 347 stainless steel for nitric acid service. Information is also needed on the corrosion behavior of various types of welding rod used for welding the two alloys.
10. Corrosion of stainless steel alloys increases in the vapor phase above nitric acid solutions with increased temperature. Type 430 stainless steel is severely attacked when cold bypass gas containing a small amount of nitric acid vapors is introduced into the lines at 750 degrees F. The austenitic alloys are attacked also but to a lesser degree.

Various stop-gap measures are being employed now to minimize damage in the manufacture and production of nitric acid. The committee hopes to provide sufficient information on the solution of these problems so remedial measures may be of a permanent rather than a temporary nature.

Small Currents Can Cause Severe Damage

The importance of small currents is illustrated by a report from a member of T-4B on Corrosion of Cable Sheaths. A buried 2-inch coated steel pipe with a wall thickness of 0.154-inch failed after three years at a point where the pipe rested on a brick. The brick, because of soil pressure, had squeezed away the coal tar coating, leaving a bare spot with an area of about one square inch.

Operating engineers were much surprised when they learned that the current discharge was on the order of .001 ampere because they were accustomed to deal with currents on the order of 100 amperes. Corrosion in the instance noted was the result of galvanic current caused by connecting the steel pipe to a buried copper ground. The reporting member felt the same corrosion could have resulted from the discharge of an equivalent value of stray railway current.

This incident caused the committee to wonder if operating personnel appreciate sufficiently the importance of small currents flowing from pipes through coating breaks. To illustrate the damaging effect of small currents the following table of corrosive rates resulting from discharge of one milliampere per square inch from various metals is given:

Anode Metal	Density (Grams per Cubic Cm)	Corrosion caused by 1 milliampere per square inch (Inch Per Year)
Magnesium	1.74	.139
Zinc	7.14	.091
Aluminum	2.72	.065
Mild Steel	7.87	.071
Lead	11.35	.182
Copper	8.92	.142

Recommendations Are Made on Plastic Pipe

Certain recommendations have been developed by Unit Committee T-1J on Oil Well Structural Plastics which may help reduce plastic pipe installation failures. These recommendations result from a survey of 73 oil well plastic pipe installations.

The recommendations concerning manufacture of the pipe include:

1. Adoption of quality control and pressure tests to eliminate weak pieces.

2. Development of stress-strain-time curves at varying temperatures in water to determine long-term strength.

Test data contributed by one committee member involving hydraulic type tests of glass-plastic pipe showed significant differences between the abilities of different types of resins to withstand constant hydraulic pressure at warm temperatures. An experimental epoxy resin-glass roving pipe withstood hydraulic pressure equipment to hoop strength of 10,000 psi at 110 degrees F and 5000 psi at 150 degrees F. A polyester and glass mat pipe failed at a hoop strength pressure of 1800 psi at 110 degrees F and 1200 psi at 150 degrees F. It was noted in these tests that the degree of superiority of the epoxy resin-glass roving material over the polyester-glass mat material was not as great in the hydraulic pressure test as in the flexure test.

A possible explanation for the discrepancy was in the manner in which the epoxy resin pipe failed. Failure was in the form of small leaks occurring at loads considerably under rupture pressure. This indicates development of porosity in laminated tubes under load is a fact that should be considered in evaluating material of this type.

With respect to use of the material certain factors were seen to be important. 1. Long-term stress data should be used in design considerations, together with an appropriate safety factor. 2. Suitable controls should be provided to prevent excessive temperatures. 3. Dresser sleeves might be used to provide slack for thermal expansion of lines. 4. Direct connection with vibrating equipment should be avoided. 5. The lines should be buried if possible.

S. E. Jack Elected Head Of Unit Committee T-6G

S. E. Jack, Aluminium Laboratories, Ltd., Kingston, Ont., has been elected chairman of Unit Committee T-6G on Surface Preparation for Organic Coatings. He is head of the Paint Section of Aluminium Laboratories and has experience in paint technology.

A foreword to a proposed report on surface preparation of aluminum has been accepted by the committee and progress is being made on the report.

A task group to draft recommendations for surface preparation of magnesium prior to painting is being formed.

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Discussions of technical material printed in Corrosion are not limited to those actually originating at the presentation of papers at meetings.

Answers to Organic Coatings Problems Given

Several answers to specific corrosion problems involving organic coatings and linings were developed during discussions at Kansas City in March among members of Unit Committee T-6A on Organic Coatings and Linings.

When asked for solution of corrosion of a large water tank emptied every three hours of water with 100 ppm calcium carbonate and magnesium carbonate with a pH of 7 to 8 at 60 to 80 degrees C. the following answers were given. 1. Some type of cathodic protection because of the size of the tank. 2. Thermosetting resin coating. There was some discussion among members that the cost of installing thermosetting resins might be excessive.

A suitable material of construction to be exposed to degreasing with an organic solvent followed by a boiling 50 percent nitric acid solution while exposed to 100 psi steam pressure in an autoclave was sought. Stainless steel was suggested.

A method was sought to prevent pitting of stainless steel containing lauryl sulfate at 100 to 120 degrees F. Minimum contamination was desired. Answers were: 1. Baked epon resin. 2. Rigid vinyl coating. 3. Baked thermosetting resin. 4. Nickel clad material.

Highly filled vinyls could be used as putty to fill pits in a hydrochloric acid tank to be coated with Saran, it was suggested in reply to another question.

Railroads Committee Studies Problems

Studies leading to mitigation of corrosion on railroad hopper cars, refrigerator cars, steam generator water tanks and small oil storage tanks were discussed at a meeting of Unit Committee T-3E on Railroads in Washington, D. C. May 17. Fifteen members and guests were present.

C. L. Crockett of Norfolk & Western Railway reported that Task Group T-3E-2 on Corrosion of Railroad Hopper Cars is continuing large scale studies to find an acceptable coating for interiors of hopper cars. Sprayed neoprene seems to be the best of those tested so far, he said.

Another member reported progress on tests of a theory that most corrosion in coal cars occurs while the coal is wet and that resulting corrosion could be reduced by cathodic protection. A miniature hopper car 6 x 2½ feet has been fitted with magnesium anodes ⅜-inch by ¼-inch around side sheets of the car positioned horizontally close to the tops of the slope sheets where most corrosion occurs. The miniature has one side made of Corten and the other of copper steel. It is filled with coal and exposed in the open. Definite indications on the effectiveness of this method should be available by the time the committee meets next, the member feels.

T-3S-2 plans to test the theory that hexametaphosphate has cathodic protection action in water. This theory will be tested in coal washers which use water and sometimes wetting agents for dust

(Continued on Page 8)

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The Society of Plastics Engineers, Inc. — John W. Le Valley, President
The Society of the Plastics Industry, Inc. — Geo. O'Connell, President
Plastic Coatings and Film Association — Ernest Kulp, President
Proprietary Plastics Manufacturers Association — Fred A. Nash, President

Accepted.
The Atlas Mineral Products Co.
Raymond A. Seymour, President

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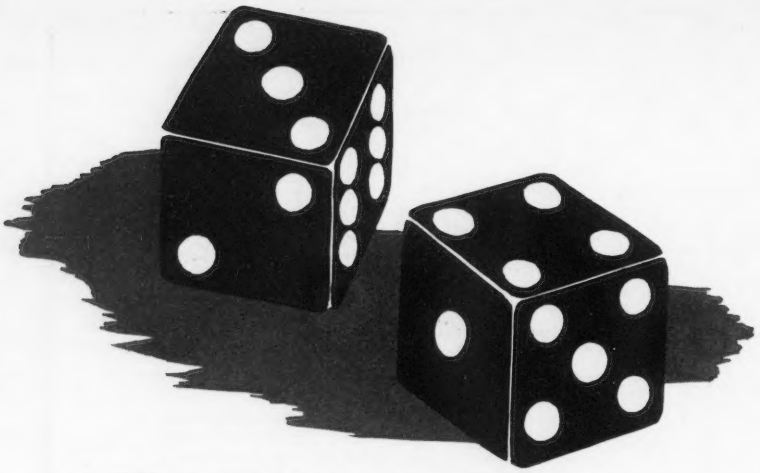

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Three NACE Members Talk Before Public Works Association

Three members of NACE spoke at the July 29 meeting of the Southern California Chapter of the American Public Works Association on the subject, Corrosion of Underground Pipelines and Its Control. The meeting was held at the Rodger Young Auditorium in Los Angeles.

Forest O. Waters, corrosion engineer of the City of San Diego Water Department, discussed soils and soil testing and exhibited instruments used to measure the corrosivity of soils.

Harry J. Keeling, consulting engineer, demonstrated how simple electric circuit theory can be used to explain pipeline corrosion and cathodic protection.

Newell W. Tune, Civil Engineering Associate, Department of Water and Power, City of Los Angeles, discussed protective coatings, their performance, relative cost and specifications.

The speakers were introduced by S. K. Gally, Southern California Gas Company, chairman of Los Angeles Section of the NACE.

State Seeks Injunction In Pollution Suit

The State of Texas is seeking an injunction against Gulf Chemical Company, Galena Park (Houston) alleging the company failed to abate a nuisance injurious to the health, rights and property of the public. Dr. Walter E. Quebedeaux, Harris County air and water pollution control unit head, testified in district court that all complaints of gas fumes he investigated led to Gulf Chemical Company. Police Chief William T. Morrison of Galena Park testified that during an investigation fumes from the plant ate holes in his uniform.

Mayor William J. Philpot of Galena Park testified there were occasions when air pollution was so great it awakened him from sound sleep and turned silver on the table black.

The chemical company makes fertilizer.

Railroad Committee—

(Continued from Page 7)

prevention. Using hexametaphosphate as an inhibitor with calcium chloride, which when used alone as an anti-freeze causes excessive corrosion, also will be suggested to the railroads.

In the discussion during the meeting it was brought out that serious corrosion problems exist in refrigerator cars leading to premature failure of hatch casings, roof sheets, inside steel sheathing and steel ends, underframes, truck sides and bolsters. Some railroads are attempting to counter refrigerator car corrosion with vinyl coatings while others are using magnesium anodes.

Steam generator water tank corrosion also was mentioned. It was suggested that the addition of an inhibitor to small oil storage tanks probably would reduce corrosion of those with a water layer in the bottom.

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Members may get the distinctive NACE membership pin for $10.

General News

Corrosion-Interest Papers Are Given at Nuclear Congress

ASTM Officers Are Named at Chicago

The American Society for Testing Materials elected seven new officers at its 57th annual meeting in Chicago, June 13-18.

Elected president was Norman L. Mochel, manager, Metallurgical Engineering, Westinghouse Electric Corp., Lester Branch; Rudolph A. Schatzel was elected vice-president. He is vice-president and director of engineering, Rome Cable Corp., 421 Ridge St., Rome, New York.

Five new members of the Board of Directors are: Edward J. Albert, president and treasurer, Thwing-Albert Instrument Co., Penn St. and Pulaski Ave., Phila.; John M. Campbell, administrative director, Research Laboratories Div., General Motors Corp., Detroit, Mich.; Paul V. Garin, engineer of tests, Southern Pacific Co., 65 Market St., San Francisco; John H. Jenkins, Chief of Forest Products Laboratories of Canada, Ottawa, Ont.; Douglas E. Parsons, Chief of Building Technology Div., National Bureau of Standards, Washington, D. C.

ASTM Authors' Awards

The American Society for Testing Materials made awards to the authors of outstanding technical papers at its 57th annual meeting in Chicago.

The Sam Tour Award was given to John T. Richards, chief engineer, Penn Precision Products for The Corrosion of Beryllium Copper Strip in Sea Water and Marine Atmospheres, presented at the 1953 meeting.

Service Awards were given also at the meeting. The Max Hecht Award to Max Hecht for outstanding service to the Committee on Industrial Water.

BOOK REVIEWS

Manual for Plastic Welding. Volume II. Polyethylene. By G. Haim and J. A. Neumann. 1954. 128 pages, 5½ x 8½, cloth binding. Industrial Book Co., 1240 Ontario St., Cleveland 13, Ohio. Per copy, $6.00.

This liberally illustrated book is designed for the person who wants to learn the technique of welding polyethylene materials of construction. Opening chapters explain generally what plastics are and describe the principal characteristics of common plastics. The history and development of polyethylene then are covered, with considerable attention to the material's mechanical characteristics, advantages, limitations

(Continued on Page 10)

Clapp Award Is Given To Admiral J. F. Jelly

Admiral J. F. Jelley, USN, Chief of Construction, National Defense, has been given the 1954 William F. Clapp Memorial Award of the Sea Horse Institute. Adm. Jelley was Chief of the Bureau of Yards and Docks, Chief of Civil Engineers, U. S. Navy and head of the Seabees from December, 1949 to October, 1953. Previously he had held various key positions related to construction in the navy. The award, presented June 9 during the Seventh Annual Marine Borer Conference cited his continued interest and activity in the field of marine borers and especially his organization of the Fourth Annual Marine Borer Conference at Port Hueneme, Cal. at the Navy Civil Engineering Laboratory there.

Adm. Jelly

NYU Surface Technology Laboratory Is Opened

A new surface technology laboratory has been opened in the Engineering Research Building No. 2, New York University, 401 W. 205 St., Manhattan.

The new laboratory is expected to facilitate research programs by centralizing formerly scattered operations and by the use of new equipment that could not be used in the previous cramped quarters.

The field of research covered by the laboratory includes painting and other organic coating of metal surfaces, treatment of surfaces by chemical and electrochemical means, spraying with metal particles and development of systematic research and evaluation methods relating to preparation of surfaces before treatment and to the application of finishes, according to Dr. Harold K. Work, director of the research division.

Facilities of the new laboratory include a salt-fog chamber, paint mills, spray equipment, a steam-exposure chamber, a Weather-O-Meter, a profile analyzer and various optical and electrical research instruments.

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Ordinarily preprint copies of papers presented at NACE meetings are not prepared by the association.

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Extra copies of CORROSION can be bought from NACE, 1061 M & M Bldg. Houston.

AIChE Session Held At Ann Arbor, Mich.

Among the technical papers of corrosion interest presented during the International Congress on Nuclear Engineering conducted by the Nuclear Engineering Division of the American Institute of Chemical Engineers at University of Michigan, Ann Arbor June 20-25 were:

Preparation, Properties and Uses of Beryllium by E. J. Boyle and J. L. Gregg, Oak Ridge National Laboratory, Oak Ridge, Tenn.

Melting and Fabrication of Zirconium by J. W. Holladay and J. G. Kura, Battelle Memorial Institute, Columbus, Ohio.

Corrosion of Zirconium in High Temperature Water by D. E. Thomas, Westinghouse Electric Corp., Atomic Power Div., Pittsburgh.

Studies in the Uranium-Bismuth Fuel System by D. H. Gurinsky and J. E. Atherton, Brookhaven National Laboratory, Upton, L. I., N. Y.

Corrosion and Impurities in the Heavy Water System of the Dutch-Norwegian Reactor by T. J. Barendregt and K. H. Brakstad, Joint Establishment for Nuclear Energy Research, Kjeller, Norway.

A Nuclear Reactor for Metallurgical Research by J. J. O'Conner and L. S. Foster, Watertown Arsenal, Watertown, Mass.

Experience with Graphite as a Fabrication Material in High Temperature Heat Transfer Systems by R. D. Keen, Atomic Energy Research Dept., North American Aviation, Inc., Downey, Cal.

Processes for High Level Waste Disposal by B. Manowitz and L. Hatch, Brookhaven National Laboratory, Upton, L. I., N. Y.

Treatment, Use and Ultimate Disposal of Radioactive Wastes by W. A. Rodger, Chemical Engineering Div., Argonne National Laboratory, Lemont, Illinois.

High Temperature Centrifugal Pumps by H. W. Savage and W. G. Cobb, Oak Ridge National Laboratory.

Gamma Ray Initiated Polymerization of Styrene and Methyl Methacrylate by D. S. Ballantine, P. Colombo, A. Glines and B. Manowitz, Brookhaven National Laboratory.

Radioisotopes in Industrial Control by G. D. Calkins and Meyer Pobereskin, Battelle Memorial Institute.

Liquid Metal Fuel Reactor Systems for Power by C. Williams and F. T. Miles, Brookhaven National Laboratory.

●

Students come from many states to attend short courses on corrosion, usually held each fall by NACE's Tulsa and Shreveport Sections.

Reports by Standing Committees and Others At General Business Meeting at Kansas City

Following are 1953-54 reports of the standing committees and others who customarily compile reports for presentation at the General Business Meeting of the National Association of Corrosion Engineers. The reports were presented at the NACE general business meeting at Kansas City on March 16 during the Tenth Annual Conference and Exhibition.

Report of Walter F. Rogers, NACE President, 1953-54

Mr. Rogers' report, given in full in the March, 1954 issue of CORROSION beginning on Page 83, reviewed generally the progress of the association during his tenure. He especially cited the reorganization of the technical committees and the work of the Educational Committee.

Report of Russell A. Brannon, Treasurer

Figure 1 shows changes in NACE membership, with the total for 1954 estimated. There are 4044 active members as of the end of 1953 and 381 corporate members. The 1954 goal is 450 corporate members, the same as that for 1953.

Figure 2 shows sources of the association's income. The largest amount comes from publications. Income during 1953 was $136,088 from publications; $51,701 from regular business and $43,538 from the conference, making a total of $231,428. Budget provisions are based on past experience, and the change in rate indicated in the anticipated increase in publication income is conservative. This may be bettered during the year. Total income for 1954 is estimated to be $268,335.

Something that should be taken into account is that while dues of active members are $7.50 annually the association collects and disburses something like $50 for each member during the year.

Figure 3 shows application of funds received. The top line is total income and as usual publication expense is the largest item. Total expense was $209,797 for the year and the difference between income and expense was an addition to equity, which at the end of 1953 was $107,492. Budget provisions follow past experience except for a sharp increase in expenses due in part to the increasing complexity of the association's operations. There will, however, be a modest addition to equity in 1954.

Some of the expenses predicted for 1954 will be the result of addition to the inventory of technical publications for sale and will represent future income. It is difficult to devise a budget on a cash basis which will show the true condition of the association's business.

Current assets at the end of 1953 were $134,593, consisting of cash, accounts receivable, government securities and an inventory of technical publications valued at $13,000.

Special funds are: Research fund and the Junior Award Fund. There are fixed assets costing $14,000, which have been depreciated annually to a current value of $8185. Deferred expenses total $4600. Current liabilities are only $1728.

Persons accustomed to examining the balance sheets of profit-making companies will find this one demonstrates an excellent cash position and ratio of current assets and liabilities. But these same persons will find something to question in current assets which cannot be sold to make a profit. This arises because the association is a non-profit association whose business is service to its members. So, most of the association's

(Continued on Page 12)

Figure 1

Standardization Urged For Terms Describing Flammable Materials

Standardization of terms describing the characteristics of materials which may be ignited or which will burn is suggested by Willard E. Edwards, with the District Public Works Office, Maintenance Engineering Division, Fourteenth Naval District, Pearl Harbor, T. H. He is a member of the National Association of Corrosion Engineers.

Mr. Edwards points out that the words "flammable" and "inflammable" frequently are used indiscriminately to describe materials which will burn if ignited. The word flammable, he points out, is preferred technically because it avoids the ambiguity inherent in the prefix "in" which frequently in English carries a connotation of "not."

He suggests therefore the following usages and concurrent definitions:

"Flammable" when referring to a material which will burn readily when ignited.

"Nonflammable" when referring to a material which will not burn readily if ignited, or which will not burn at all under ordinary conditions.

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Discussions and comments on material in Corrosion's Technical Section are welcomed for review prior to publication.

BOOK REVIEWS

(Continued from Page 9)

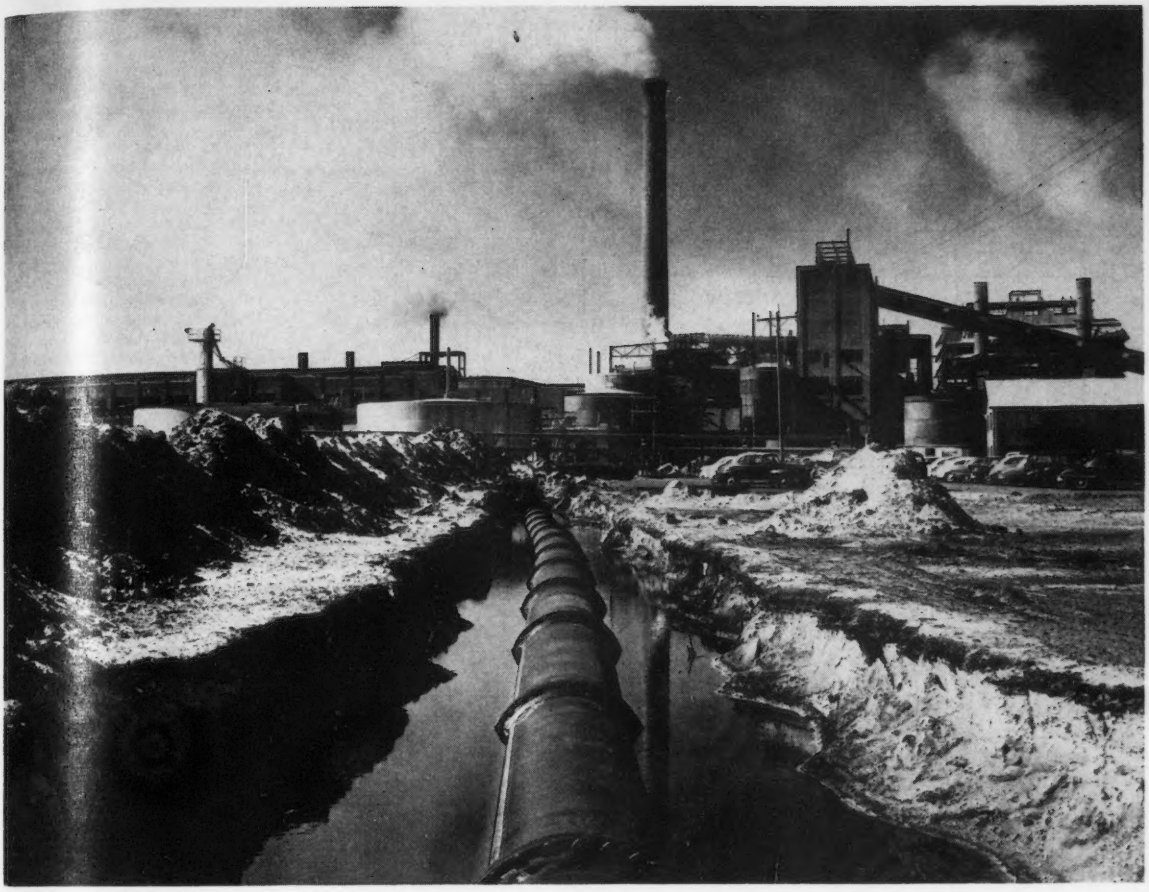
and the shapes, thicknesses and dimensions of the parts which may be made of it.

Chapter IV gives a history of the welding of plastics, attributing discovery of the method to R. C. Reinhardt of Dow Chemical Company in 1937. Succeeding chapters describe and illustrate welding equipment, explain details of the process in step-by-step fashion, describe the types of welds suitable for polyethylene, lining of tanks, fabrication of pipe lines and fittings and the scope of fabrications and industrial applications of the material. The appendix includes a table giving resistance of the materials to various concentrations and temperatures of corrodents.

Welding Alcoa Aluminum. 176 pages, 5¼ x 8¼, paper. 1954. Aluminum Company of America, 1501 Alcoa Bldg., Pittsburgh. Free.

This successor to the Alcoa booklet Welding and Brazing Alcoa Aluminum brings up to date the information on aluminum welding. Brazing will be covered in a booklet to be issued later.

The booklet covers theory and technique in inert gas tungsten welding, inert gas consumable electrode welding, spot and seam welding, flash welding; metal arc, carbon arc, atomic hydrogen welding; gas welding; welding aluminum castings, pressure welding, performance, quality control, and safety. Numerous tables of data on mechanical properties are given and illustrations are included of types of welds. A topical index is included.



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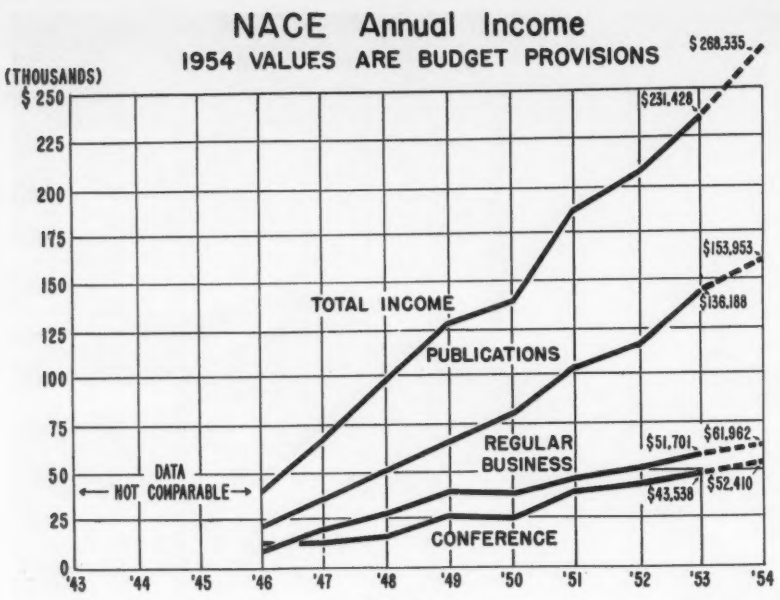


Figure 2

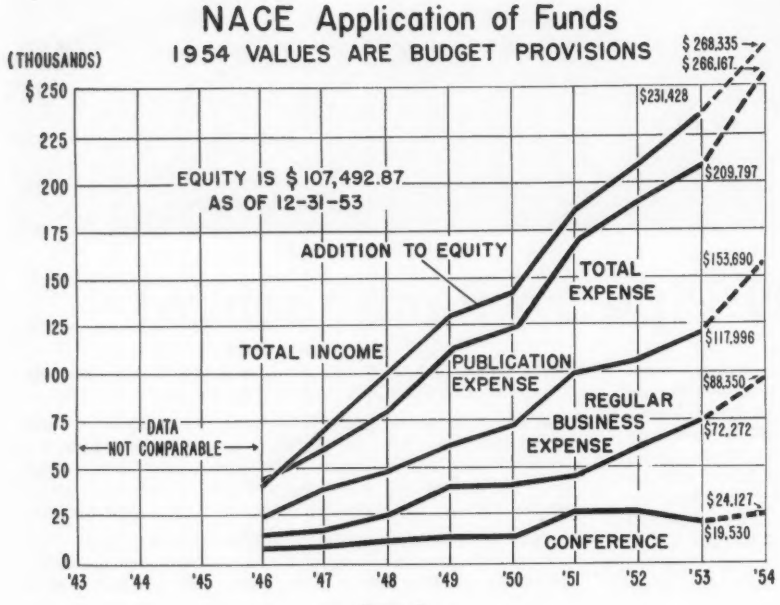


Figure 3

Reports by Standing—

(Continued from Page 10)

current assets are invested in bonds at 3 percent.

Report of Policy and Planning Committee by E. P. Noppel, Chairman

The function of the Policy and Planning Committee is to advise the board of directors on matters of policy referred to it by the board. The committee makes recommendations to the board on all matters of long-term policy and many other matters having to do with policy questions in connection with the day-to-day functioning of the association and is also empowered to initiate recommendations to the board on appropriate matters for the good of the association. All recommendations of the committee are submitted to the board and can be made effective only upon approval and action by the board.

The work of the committee is of a continuing nature and the committee consists of six members in addition to the chairman. Appointments to the committee are made so that one-third of the six members shall be replaced each year, with each member serving a three-year term. The chairman and the members of the committee are appointed by the president and the president, vice-president and secretary of the association are members ex-officio.

Because of the nature of the work of this committee, every effort has been made to have it as representative as possible of the membership of the association, both on a geographic and industry basis. The present membership of the committee comprises the following:

J. C. Stirling, Service Pipe Line Co., P. O. Box 1979, Tulsa, Okla.
E. D. Verink, Jr., Aluminum Co. of America, P. O. Box 1012, New Kensington, Pa.
D. E. Stearns, The D. E. Stearns Co., Shreveport, La.
J. T. MacKenzie, American Cast Iron Pipe Co., Birmingham, Ala.
E. R. Stauffacher, Southern California Edison Co., Los Angeles, Cal.
D. C. Glass, Pure Transportation Co., Chicago, Ill.
E. P. Noppel, Chairman, Ebasco Services, Inc., New York, N. Y.

A meeting of the committee was held in Chicago, Illinois on March 16, 1953 at the time of the annual convention, at which a number of association problems having to do with policy and planning were discussed and acted upon. In view of the widespread representation, much of the committee work must be done by correspondence and in numerous instances handled by the chairman.

Some of the matters given consideration and study by the committee during the past year are the following:

1. Preparation of model "Rules and Regulations" for NACE Sections.
2. Preparation of model "Rules and By-Laws" for NACE Regional Divisions.
3. Preparation of preliminary recommendations regarding procedure for subdivision of sections where they have become too large and it is found desirable to create several sections in place of an existing section.

Numerous other matters of lesser importance were considered by the committee through its chairman and opinions on interpretation of the by-laws and articles of organization were given to the president and executive-secretary of the association from time to time as the need for clarification arose during the year. Among these were:

(a) Comments as to when a new section becomes eligible to receive funds advanced by the association.
(b) Review and comment on rules regulations of the Greater Kansas City Section.
(c) Review and comment on amended rules and by-laws of the South Central Regional Division.
(d) Review and comment on amended rules and by-laws for the South Eastern Regional Division.
(e) Review and comment on certificates issued to sections having to do with the placing of the corporate seal and effective dates, etc.

It is the desire of the chairman and every member of the committee to be responsive to the needs of the association, and the committee will welcome ideas and suggestions from the membership on matters of policy and planning which will further the best interests of the Association.

Report of the Technical Practices Committee by H. W. Schmidt, chairman

A fairly comprehensive report was prepared August 6, 1953 for presentation at the executive committee meeting

(Continued on Page 13)

Reports by Standing—

(Continued from Page 12)

August 11, 1953 and included in the minutes of that meeting. In general, the material given in that report will not be repeated.

An important forward step was taken with the adoption of a reorganization plan and a procedure manual for the TP Committees. These are described fully in the January 1954 CORROSION. It is felt that more adequate administration can be exercised and a more effective committee will result.

The committees have been active and made considerable progress.

Reports of committee activity were published in the form of four papers as follows:

TP-1—Sponsored Oil and Gas Production Symposium at the 1953 Conference consisting of three papers, two of which are: Studies on Water-Dependent Corrosion in Sweet Oil Wells by H. E. Greenwell, Corrosion, September, 1953; Corrosion of Casing in Oil and Gas Wells, Corrosion, September, 1953.

TP-6G—Surface Preparation of Steels for Organic and Other Protective Coatings, Corrosion, May, 1953.

TP-16B—Cable Sheath Corrosion and Prevention by B. B. Reinitz, Corrosion, November, 1953.

Two other reports have been approved and will be published in an early issue of Corrosion.

TP-1—Laboratory Methods for the Evaluation of Inhibitors for Use in Oil and Gas Wells by E. C. Greco and J. C. Spalding.

TP-19—Corrosive Effects by De-icing Salts, published in January, 1954 Corrosion.

Work by a number of committees has reached the point where interim reports have been prepared. If the following can be completed and approved at the March meeting, publication should be possible during the year.

TP-1—Four papers in a symposium to be sponsored by TP-1 at the 1954 Conference.

TP-3—Results of four year test program on anodes with impressed currents.

TP-4—Some Observations of Cathodic Protection Criteria in Localized Pitting. Compilation of information on protective criteria and minimum current requirements.

TP-6A—Coatings and Linings for Chemical Corrosion.

TP-6B—Coatings for Atmospheric Resistance.

TP-6C—Coatings for Resistance to Marine Corrosion.

TP-7—Compilation of High Temperature Corrosion Data.

TP-13—Three papers in a symposium on Costs of Corrosion to be sponsored at the 1954 Conference.

TP-16A—General procedure for the bonding of lead cable sheaths for corrosion mitigation.

TP-17—Procedure for measuring pipe coating leakage conductance.

The problem of completing and publishing reports of activities is of the greatest importance to NACE. Efforts will be made to emphasize this need to publish information whenever possible. Since all of these efforts are "labors of love," progress at times is of necessity very slow.

One of the duties of the proposed paid TP Committee secretary could be to render assistance to the various committees in finishing reports once the technical data are well organized, making editorial corrections and suggesting to the committees that a report should be prepared on a project which has been under study but when there is a tendency to dispose of it by reporting the details in the minutes of a meeting and then forgetting it.

New activities of the various committees not reported previously can be summarized as follows:

TP-1—This committee held a meeting at the time of the South Central Regional meeting in Tulsa, Oklahoma. No report has been received but the committee was active.

TP-3—A. W. Peabody, vice chairman. A cooperative effort with the National Electric Manufacturers Association on the preparation of specifications for rectifiers for cathodic protection service.

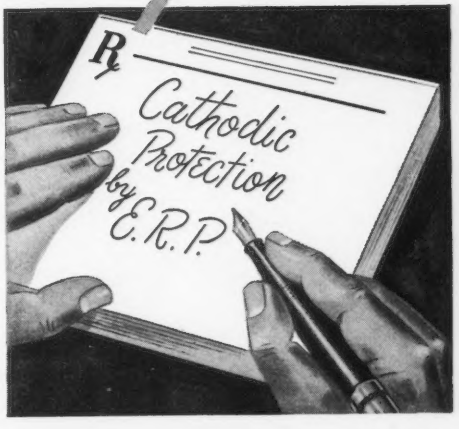
TP-4—L. P. Sudrabin, chairman. Considering a change in title and scope of committee. Will consider preparations of specifications for protective criteria measurements.

TP-5—P. J. Gegner, chairman. TP-5A will be disbanded unless an active program can be developed at the March meeting.

TP-5C—R. I. Zimmerer, chairman. Is active in completing literature search on corrosion by chlorine. Work is under way by the Pennsylvania Salt

(Continued on Page 14)

℞ FOR CORROSION...



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Reports by Standing—

(Continued from Page 13)

Company on corrosion tests and test methods for non-metallic materials.

TP-5G—J. L. English, chairman. Corrosion by Nitric Acid Committee has six projects under way.

TP-6—A. J. Liebman, chairman. Two new sub-committees have been formed; TP-6L, Asphalt Type Underground Protective Coatings and TP-6R, Coordinating Committee on Protective Coatings. The scope of the latter committee designated as research may be too broad. This will be discussed at the meeting in March.

TP-8—V. V. Kendall, chairman. No activity has been reported on the project "Seasonal variations in analysis of domestic waters." If this project cannot be activated, it should be disbanded.

TP-8A—C. P. Dillon, chairman. Committee on Gulf Coast Cooling Waters is active. Data are being collected on this project.

TP-11—C. E. Imhoff, chairman. Compiling bibliography. Have established liaison with Joint Committee for Chemical Analysis by X-Ray Diffraction Methods. Planning on establishing liaison with Comite International De Thermodynamique Et De Cinetique Electrochimique.

TP-13—F. N. Alquist, chairman. Will sponsor symposium on Cost of Corrosion at the March meeting. Three papers are planned. This committee has not been too active. If a program cannot be developed, it will be disbanded.

TP-18A—J. C. Watts, chairman. The committee is working on a report covering methods of control. The report was divided into several parts and assigned to members. Progress is reported.

TP-18B—Ivy M. Parker, chairman. The design of in-line test coupons has been completed. Preliminary tests are being run to determine sensitivity of available materials. The C. J. Fritts Company of Dallas, Texas, will prepare specimens and the operating companies will purchase their specimens. These will be exposed in flowing section of products pipe lines and rated according to schedule set-up, and will be reported to committee. This will permit each operator on the committee to compare inhibitor efficiency of his line with other operations. From this, the committee can develop suggested procedures for obtaining best results.

TP-19—F. E. Kulman, chairman. The committee has just published a report. At the March meeting the following items will be considered for future activity.

1. Additional field testing to determine more accurately the increased corrosion rates caused by de-icing salts.
2. Further field testing to determine the increased amounts of inhibitors required to counteract corrosion.
3. Non-corrosive chemical substitutes for melting snow and ice.

Two new sub-committees are being formed:

T-4F—Materials Selection for Corrosion Mitigation in the Utility Industry.

T-3F—Corrosion by High Purity Water at Elevated Temperatures

Several of the committees are cooperating with other technical societies. In the past, appointments have been made and as far as can be determined, there does not seem to be any follow-up or reports made. The records show the following committees are cooperating with some other technical soceity.

TP-3—National Electric Manufacturers Association on specifications for cathodic protection rectifiers. This project is in formative stage and no appointment has been made.

TP-6—Steel Structures Painting Council. A. J. Liebman; V. V. Kendall, alternate.

TP-6—Federation of Paint and Varnish Production Clubs. Dr. Robert Steiner.

TP-6—Technical Coordinating Committee for the Paint Industry, National Paint, Varnish and Lacquer Association. Kenneth Tator.

TP-6—National Security Industrial Association.

TP-11—Joint Committee for Chemical Analysis by X-Ray Diffraction Methods. Dale Vaughan.

Intersociety Corrosion Committee. H. W. Schmidt; G. W. Seagren, alternate.

The Technical Coordinating Committee for the Paint Industry and the National Security Industrial Association projects have not reported for several years. The representative will be contacted to determine if these are active.

The Federation of Paint and Varnish Production Clubs have carried on a correspondence for several years. They are apparently now at a point where a program is to be started. It appears that the project will consist of research work at some university. No mention is made as to who will provide the funds.

One of the basic problems is the continued growth of the Technical Practices Committee. The principle that is presently being followed is that growth should be the result of spontaneous demand on the part of NACE members. When there is a definite need expressed for an activity and enthusiasm to do something about it is provided, then a committee can expect progress. Without these requisites, activity will flounder and results almost impossible to attain.

It is felt that many effective projects can be vitalized at a local level. Many NACE members find it virtually impossible to travel great distances to attend national meetings. If activities can be established within a region or section, a small group can work on mutual problems. These same problems may be vital to small groups in other sections. The national organization would coordinate these activities and provide for the communication between sectional groups. It is felt that by discussing this problem with the Regional Management Committee during the March meeting the interest of the sections and regions in the proposal could be determined.

Report of Publication Committee by R. B. Hoxeng, chairman.

A detailed summary of the activities of the Publication Committee will not be read at this annual business meeting. Rather, I shall emphasize what I consider to be high points of the year's publication activities. The following people have served on the Publication Committee: Miss Marguerite Bebbington, Mr. G. Diehlman, Dr. T. P. May, Dr. Ivy M. Parker and Mr. E. R. Stauffacher. To these individuals, to their subcommittees and to Messrs. A. B. Campbell, N. E. Hamner and the rest of the Central Office Staff, the association is greatly indebted for the continued growth of the publication activities.

Before reviewing the publication activities, I should like to remind you that publications in one form or another constitute a major activity of our association. Last year the total income of the association, exclusive of the conference, was about $188,000. Of this amount, $136,000 or about 75 percent was derived from publication activities. Furthermore, the publication activities last year showed a net over expenses of about $16,000, or almost 9 percent. Although large profits are not our aim, it is very satisfying to know that our extensive publication activities are paying their way in this growing organization.

Furthermore, Corrosion activities are keeping pace in their growth with that of the Association. During 1953, the circulation of CORROSION to members increased 12 percent and the circulation to nonmembers increased 14 percent. It is pertinent to note that our income from nonmember subscriptions is an important item, amounting in 1953 to about $11,000, as compared to the $16,000 of membership dues allotted to publication activities. Revenue from advertising in 1953 was $92,000, an increase of 24 percent over the 1952 income of about $75,000.

The number of technical articles published in 1953 was 8 percent greater than in 1952 and these articles occupied 6.6 percent more pages. The pages of news published about activities of interest to the Association increased 8 percent. These increases in technical material and news were offset by decreases in pages of abstracts and published discussion, so that the total number of pages in the journal remained about the same.

The responsibilities of our editor, Dr. Parker, and of our business manager, Mr. Hamner, have grown in proportion to the growth of CORROSION. The association is indeed fortunate in having the continued services of these individuals.

Likewise, the work of the Editorial Review Subcommittee has increased in that almost 100 manuscripts were received for review during the last year. This subcommittee, under the able chairmanship of Dr. T. P. May, has included Messrs. G. Diehlman, I. C. Dietze, J. J. Harwood, V. B. Pike, J. W. Ryznar, A. W. Tracy, and R. S. Treseder.

Other publication activities during 1953 included preparation of our third bibliographic-survey volume, in which there are about 3500 abstracts of corrosion articles that appeared in the world literature. These abstracts cover the two-year period 1948-1949. The association now has three bibligraphic-survey volumes that include about 7500 abstracts for the period 1945 through 1949. All abstracts are extensively cross-indexed. The fourth volume, for the years 1950 and 1951, is now being prepared and should be available prior to the next convention.

Mention should also be made of the NACE Abstract Punch Card Service. During 1953, an additional 2000 corrosion abstract cards were published. More than 6000 cards have now been

(Continued on Page 15)

Reports by Standing—

(Continued from Page 14)

published, with abstracts of corrosion articles primarily for the period 1949 through 1952. These abstract cards are extensively cross-indexed and are now being prepunched by the NACE for 322 sub-classifications. With this cross-indexed and are now being prepunched by the NACE for 322 sub-classifications. With this cross-indexing, the subscriber can readily fin dthe existing information on tens of thousands of subject combinations. The Abstract Subcommittee, under the chairmanship of Miss Bebbington, has included Drs. H. Godard, G. H. Cloud, N. Hackerman, R. D. Misch and I. M. Parker.

Before closing this report, I should like to say just a few words about 1954. We are looking forward to the publication of another bibliographic-survey volume for the years 1950-1951 and of another 2000 abstract punch cards, mostly of articles that appeared in 1952 and 1953. Within a few months, the association will publish a Yearbook for the NACE which will include complete directories of the membership and of all committees and will include a brief description of the aims, purposes, and history of the association. Finally, we are looking forward to bigger and better monthly editions of CORROSION. As I said last year, "CORROSION is your journal. It is you who must provide the technical articles on which CORROSION depends." With your help, 1953 was better than 1952; and we are expecting you to permit this growth to continue through 1954.

Report of Regional Management Committee by L. A. Baldwin, chairman.

Since last year's report to the general business meeting we can advise that progress in the formation of new sections has continued at an even greater rate. As of today we have 40 sections as compared to 30 last year. As predicted in last year's report, the Canadian Region is fully organized and functioning with 5 sections.

At the Regional Management Committee meeting held in Chicago last year, over forty members attended. The new model rules and regulations were discussed as well as the revision of the model rules and by-laws for regions. These have since been approved by the board of directors.

Some form of recognition for outgoing officers of regions and sections was discussed at considerable length. At the next committee meeting on Thursday morning, samples of certificates that have been used by other societies will be shown.

Considerable discussion was devoted to ways and means for the regions and sections to help in the corporate membership drive. A resolution was made and passed that a strong committee be set up on a national basis with similar committees at the regional and sectional level to increase corporate as well as active membership. Your president, Mr. Walter Rogers, has set up such committees.

We plan to hold a meeting Thursday, March 18, at 10:00 a.m. in Room 502 to continue the work of the committee. All regional and sectional officers have been invited by mail. It is planned to have as many national officers present as possible.

Mr. Schmidt, Chairman of Technical Practices Committee, will attend and discuss a proposal for technical committee work at regional and sectional levels. We believe this can be a most important means of increasing the usefulness of this most important committee. In addition, we have a full agenda and hope for a larger turnout at this meeting next Thursday.

Report of Committee on Education by Norman Hackerman, chairman

These are the notes of the committee meeting at Kansas City on March 15, 1954. Those present were Pierre Van Rysselberghe, Aaron Wachter, F. L. Whitney, Jr., and Norman Hackerman.

1. **Junior Award.** This committee will continue to choose the awardee and to this end there was some discussion as to procedure. It was agreed that authors of technical notes or review papers, although otherwise eligible, would not be considered. Mr. Hamner was requested to send to the committee members the names of eligible authors each month. The members are not bound by the rating forms; the principle is that authors or co-authors of good, original, clearly written, suitably illustrated papers would be in the final selections. Single authorship would carry more weight than dual authorship. The person selected by each individual would almost certainly reflect aspects different in such subtle ways that an attempt to reduce them to rote is useless.

(Continued on Page 16)

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Reports by Standing—

(Continued from Page 15)

2. **Syllabus for Short Courses.** This was suggested at least twice in the last year or so by Aaron Wachter and the chairman has promised again to get up a rough outline. Maybe this year.

3. **Western Region Short Course Plan.** The group agreed that the Western Regions plans for regular rotation of a general short course in each of three years in Southern California, Northern California and in the Pacific Northwest was satisfactory. The region would be expected to watch for signs of saturation and slow down as needed. The plans for special-type short courses in conjunction with the Western Region's Annual Conference was considered definitely desirable.

4. **Short Course in Southeast Region.** The chairman's action in answering a request for information from the director of that region with a suggestion for a general short course at Georgia Tech in the fall of 1954 was approved.

5. **Short Course in Canadian Region.** There has been a query from this region with a view to holding a general short course at the University of Toronto in the fall of 1954. It was agreed that there was no reason not to do so.

6. **University of Wisconsin Short Course.** The second of these at Madison is just over and the director of the course, Professor Grogan, has indicated that the university will hold another at this time next year. These last three days and are of the general type. The committee saw no reason not to give NACE co-sponsorship again.

7. There has not been time to complete plans for the corrosion engineering classes which were proposed by Aaron Wachter and which the committee is interested in having offered. The present plan is to have them given initially at a regional annual conference.

8. There was some discussion about a short course in corrosion given by the Atlas Powder Company. There was no action, as this does not lie within the province of the committee.

Report of General Conference Committee by Harry K. Phipps, chairman.

At the outset I want to say that it has been a pleasure and an honor to have served as your general chairman for this, the Tenth Annual Conference of NACE. This job has been made relatively easy by reason of the loyal and untiring work of the technical committee headed by Dr. Frank Whitney and Mr. Bilhartz; the exhibits committee headed by O. E. Murrey; and the local arrangements committee headed by Charlie Keane and G. A. Venneberg.

In the interest of time we will dispense with the reading of the names of the various committee members; however, this omission should not be taken as evidence of a lack of appreciation. I therefore want to take this opportunity to thank them publicly; and also Barry Campbell and the Central Office staff for the splendid job that they have done.

As indicated in the program, there will be thirteen symposia, two round-table discussions, three educational lectures, and two movies to be shown on three separate occasions. The above will include forty-five papers to be presented during the week.

In connection with the exhibition, this year there were 141 booths, of which 136 have been sold to 97 companies. This compares with 119 in 1953. The estimated income from the booth sale is $52,410, with expected expenses of $24,128, leaving what we hope will be a net of $28,282.

At this point I want to emphasize, as has been done on previous occasions, the great part that the exhibitors play in making these conferences possible. We have tried to recognize that, particularly this year, by providing time each morning for visiting the exhibition and so indicated that in the program. We do hope that every one will take time to visit the exhibition on as many occasions as possible.

Arrangements have been made for the banquet to be held at seven o'clock in the Grand Ballroom of Hotel Muehlebach Wednesday evening, and the Fellowship Hour to be held at the same place Tuesday evening at six o'clock. In the past we have held the banquet on Thursday evening, but this year we thought we would hold it on Wednesday in the hope it would fit the schedule of members a little bit better, in that the ones who are limited in time and can't stay the whole week would at least have the opportunity to attend the banquet on Wednesday.

In closing this report I wish to acknowledge the cooperation and assistance that has been received from the Kansas City Chamber of Commerce Convention and Visitors Bureau, the Israel Transfer Company, Exhibitors Service, Inc., American Chair Company, the four major hotels, and the management of the municipal auditorium in helping to make this conference the success we feel it is going to be.

Report of Inter Society Corrosion Committee by H. P. Godard, chairman.

Membership—The Inter Society Corrosion Committee was organized in 1948 and is composed of delegates from 36 societies and organizations interested in the control of corrosion. It is responsible to each organization as well as to NACE, its sponsor.

Annual Report to Members—All member organizations prepare a statement on their corrosion activities during the previous year. Last year, 26 of our then 32 member groups submitted such reports. These are reproduced and distributed to all delegates and headquarters. These reports, together with the minutes of the annual meeting of ISCC (which is held during the National Convention of NACE) constitute the annual report of ISCC to its members.

ISCC Glossary of Terms Used in Corrosion—During the year Mr. J. J. Harwood and his subcommittee on terminology completed the initial ISCC glossary which should be issued shortly. The first effort consists of a revision of 22 terms in the Corrosion Handbook glossary. Work is now under way to add a substantial number of new definitions.

Relations with Foreign Technical Organizations—The foreign relations subcommittee, under the chairmanship of Mr. F. L. LaQue, has been very active during the year. At our last meeting the following scope was adopted:

1) To prepare and maintain a mailing list of correspondents in foreign countries active in the corrosion field and interested in the activities of ISCC.

2) To obtain from each foreign correspondent an annual report or review of corrosion activities in his country. A copy of this is to be appended to the minutes of the annual meeting of ISCC.

3) To assist foreign corrosion workers in making suitable contacts with their counterparts in North America.

4) To assist North America corrosion workers in making suitable contacts with their counterparts abroad.

Implementing item 1), correspondents have now been established in the following 16 countries: Australia, Austria, Belgium, Denmark, England, France, Germany, Holland, Italy, Japan, New Zealand, Norway, South Africa, Spain, Sweden, Switzerland.

The 1953 reports are beginning to come in and consideration is being given to their publication in Corrosion Magazine.

Statement on Unscientific Devices Alleged to Prevent Corrosion—At the 1953 annual meeting of ISCC Dr. N. E. Berry was appointed chairman of a subcommittee to prepare a statement on the hazards of using gadgets or devices of an unscientific nature to prevent corrosion. The statement was published in Corrosion (August 1953) and in the journals of many member societies as well as in a large number of trade journals. One firm purchased 100 copies of the statement for distribution to technical personnel in its several plants.

Request for Information from Norway—A request for information from Norway on tanker corrosion problems was received and referred to the five member organizations most likely able to be of assistance. The file was then summarized briefly and distributed to all delegates.

Report of Executive Secretary A. B. Campbell.

Because the various Association activities are covered in other reports at this meeting, this report will be confined to the work and functions of the Central Office.

The lease for the rental of the space occupied by the Central Office in Houston was renewed about two weeks ago. The renewed lease will expire May 31, 1955.

The number of employees of the Association has increased by two since the end of 1952, bringing the total to twenty-one persons at the Central Office. During 1953, the membership increased by 590 as compared with 712 during 1952.

The correspondence that comes to the office has increased tremendously. It is no exaggeration to say that nearly every Monday the mail to be opened and handled amounts to from one hundred fifty to two hundred pieces of mail. Some of this is routine, but it all must be opened and looked over and some requires from a few minutes to several hours to obtain the information necessary to make adequate replies. Normally, the amount of mail received during the remainder of the week is somewhat less. During 1953, the number of letters mailed or telegrams sent from the Central Office was approximately 10,000. This does not include form letters, of which there were several thousand, or copies of correspondence.

The sections and regions have been requesting stationery and the addressing of envelopes for mailing notices, letter ballots, etc. to their members. During

(Continued on Page 18)

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- Active and Junior NACE members may run without charge two consecutive advertisements annually under this heading, not over 35 words set in 8 point text type.
- Firms seeking employees, regardless of NACE membership, may run an advertisement of the same specifications indefinitely.
- Advertisements to other specifications will be charged for at standard rates.

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Sales Representatives for DEL Protective Coatings. Protected territories available to qualified individuals or companies. No objection to carrying non-competitive lines. Write David E. Long Corp., 220 East 42nd St., New York 17, N. Y.

Corrosion Engineer—Graduate engineer with field and design experience in cathodic protection systems. Extensive travel. Salary open. Harco Corp, P. O. Box 7026, Cleveland 28, Ohio.

Metallurgist—Wanted, recent graduate in metallurgy or metallurgical engineering with limited experience to operate metallurgical laboratory engaged in study of mechanical and corrosion failures of chemical process equipment. Located on Texas Gulf Coast. CORROSION, Box 54-19.

Sales Engineers—Good territories available for qualified men to sell well-known line of protective coatings. Salary and commission, plus expenses. Prufcoat Laboratories, Inc., 50 East 42nd St., New York 17, N. Y.

Positions Wanted

Electrical Engineer, BSEE, 38, married, veteran. Experience estimating, design and supervision of installations of power control, telemetering, carrier, radio, instruments, cathodic protection, etc. on industrial and gas pipe line. Summary on request. CORROSION, Box 54-10.

Metallurgist—MS, age 31, married. Extensive work in liquid metal, fused salt and aqueous corrosion. Report writing and supervisory experience. Want responsible research or development position in corrosion or physical metallurgy, Write CORROSION, Box 54-12.

Research Director or chief materials engineer. 25 years' experience. Full knowledge design, development, production problems. Presently head of research laboratory supervising chemists, physicists, metallurgists and materials engineers. CORROSION, Box 54-15. (aug.

Metallurgical Mining Engineer—Law degree also, seeks suitable executive, administrative position. Registered professional engineer, experienced corrosion, metallurgy, mining, production, research, government specifications, technical report interpretation. Presently self-employed. Available immediately. Write CORROSION Box 54-13.

Plant Engineer—Experienced development, project engineering (electrical, chemical, mechanical, ceramic), maintenance, cost reduction, application of corrosion engineering including metals, paints, lubricants, plastics and ceramics. Desire responsible position in East. Age 42, married. CORROSION Box 54-14.

Physical Chemist—PhD with BS in chemical engineering, age 34. Eight years experience in petroleum and chemical industries. Process engineering and investigations. Five years corrosion research in field and laboratory. Publications and patents. Experience in petroleum production, refining, transportation. Desire position group leader corrosion research and technical service. CORROSION—Box 54-20.

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Reports by Standing—

(Continued from Page 16)

the year some 25,000 sheets of stationery have been printed at the Central Office for regions and sections and more than 41,000 envelopes addressed from our mailing stencils for mailings for meetings, letter ballots, etc.

Advancement of money to sections from National funds varied from none to over $500 during 1953 for one section. The total advanced to regions and sections in 1953 was $4818.75.

Membership at the end of 1953 was 4045 active members, 51 junior members and 381 corporate members. The increase since the first of the year has been 252 active members, a loss of 3 junior members, and a net increase of 4 corporate members. At the end of 1953, *272* members were dropped for non-payment of membership dues. This is substantially more than in previous years. The corresponding numbers were 172 in 1952, and 100 in 1951.

As has been mentioned, we receive a number of requests for technical information from all parts of the world. Presumably some feel that since the word "Corrosion" appears in the name of the association, we must have all the information that exists on any phase of corrosion ready to put in the mail on short notice. We can furnish a great deal of information and refer those who inquire to much more but it is difficult to answer some of these inquiries. In general, we try to supply as much information as we can and then refer inquiries to qualified individuals to answer the inquiries direct.

In a report I made about six years ago, I expressed the hope that there would be a substantial increase in the number and activities of local sections because that, I thought, would be the way that more people would learn about the importance of corrosion problems and what could be done about them through the NACE. The hope was also expressed that there would be an increase in the activity and interest in technical committees. At that time we had no more than three or four sections and three technical committees, two of which had not then formed a program on which to proceed on the problems within their respective fields. Much progress has been made in both of these. One was reported on by Mr. Baldwin, chairman of the Regional Management Committee, and the other by Mr. Schmidt, chairman of the Technical Practices Committee. These are real accomplishments by the association and open an opportunity for great progress.

These accomplishments together with our publications, the medium through which our technical information is made available, is a record that the association can be proud of. There is much to be done yet before the regional and sectional organizations and our technical committees are functioning as we all hope for, but progress is being made. With constant and persistent effort, these two parts of the association can, and I am sure will, produce beneficial results.

Since the board of directors authorized issuing certificates to local sections, a number of these have been requested and issued. The board is considering issuing a membership certificate to be

(Continued on Page 20)

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Inter Society Corrosion Committee

CORROSION MEETINGS CALENDAR

Sept.

1-16 International Electrotechnical Commission, Golden Jubilee Meeting, University of Pennsylvania, Philadelphia, Pa.

8-10 Pacific Coast Gas Association, Victoria, British Columbia.

12-16 American Institute of Chemical Engineers (National Meeting) Hotel Colorado, Glenwood Springs, Colo.

28-29 Texas Mid-Continent Oil and Gas Association, Baker Hotel, Dallas, Texas.

Sept. 28-Oct. 1 Iron and Steel Exposition, Cleveland Public Auditorium, Cleveland, Ohio.

Sept. 29-Oct. 1 Porcelain Enamel Institute, Annual Meeting, The Greenbriar, White Sulphur Springs, West Virginia.

Oct.

3-7 The Electrochemical Society, Fall Meeting, Boston, Mass.

11-14 American Gas Association, Annual Convention, Atlantic City, New Jersey.

11-15 American Institute of Electrical Engineers, General Fall Meeting, Hotel Morrison, Chicago, Ill.

12-15 National Association of Corrosion Engineers, South Central Regional Meeting, Dallas, Texas.

17-23 American Society for Metals (National Metal Congress and National Metal Exposition), Hotel Statler, Cleveland, Ohio.

28-29 American Society of Mechanical Engineers (Fuels-AIME Coal Conference), Hotel William Penn, Pittsburgh, Pennsylvania.

Nov.

1-3 American Institute of Mining and Metallurgical Engineers, Institute of Metals Division, Fall Meeting, Sheraton Hotel, Chicago, Ill.

1-5 National Metal Exposition, Chicago, Ill.

8-11 American Petroleum Institute, Conrad Hilton Hotel, Chicago, Ill.

14-18 National Association of Corrosion Engineers, Western Regional Division meeting, Los Angeles, California.

15-18 American Gas Association, Operating Section, Organization Meetings, Hotel New Yorker, New York.

28-Dec. 1 American Society of Refrigerating Engineers (50th Annual Meeting), Hotel Ben Franklin, Philadelphia, Pennsylvania.

28-Dec. 3 American Society of Mechanical Engineers (Annual Meeting), Hotel Statler, New York, New York.

Dec.

12-15 American Institute of Chemical Engineers (Annual Meeting), Statler Hotel, New York, New York.

1955

Feb.

16-18 National Association of Corrosion Engineers (Sixth Annual Pipeliners Short Course) Mayo Hotel, Tulsa, Oklahoma.

March

28-April 1, 9th Western Metal Congress and Exposition, Pan-Pacific Auditorium, Los Angeles, California.

May

1-14 American Institute of Chemical Engineers, Shamrock Hotel, Houston, Texas.

9-13 A.G.A. Industrial Gas School—(location to be announced).

16-18 Southern Gas Association, New Orleans, Louisiana.

June

5-9 Canadian Gas Association, Annual Meeting, General Brock Hotel, Niagara Falls, Ontario, Canada.

12-17 American Water Works Association Annual Conference, Chicago, Illinois.

13-18 American Society of Mechanical Engineers (75th Anniversary Meeting), Congress and Hilton Hotels, Chicago, Illinois.

Oct.

17-19 A.G.A. Annual Convention, Los Angeles, California

17-21 National Metal Exposition, Detroit, Michigan (A.G.A. will exhibit).

Nov.

13-18 The American Society of Mechanical Engineers, Congress & Hilton Hotels, Chicago, Illinois.

27-30 American Institute of Chemical Engineers (Annual Meeting), Statler Hotel, Detroit, Michigan.

1956

Oct.

15-16 National Metal Exposition, Philadelphia, Pa. (A.G.A. will exhibit).

29 to Nov. 1 A.G.A. Annual Convention, Atlantic City, New Jersey.

Nov.

25-30 The American Society of Mechanical Engineers, Statler Hotel, New York, New York.

1957

Oct.

21-25 National Metal Exposition, Cleveland, Ohio (A.G.A. will exhibit).

Reports by Standing—

(Continued from Page 18)

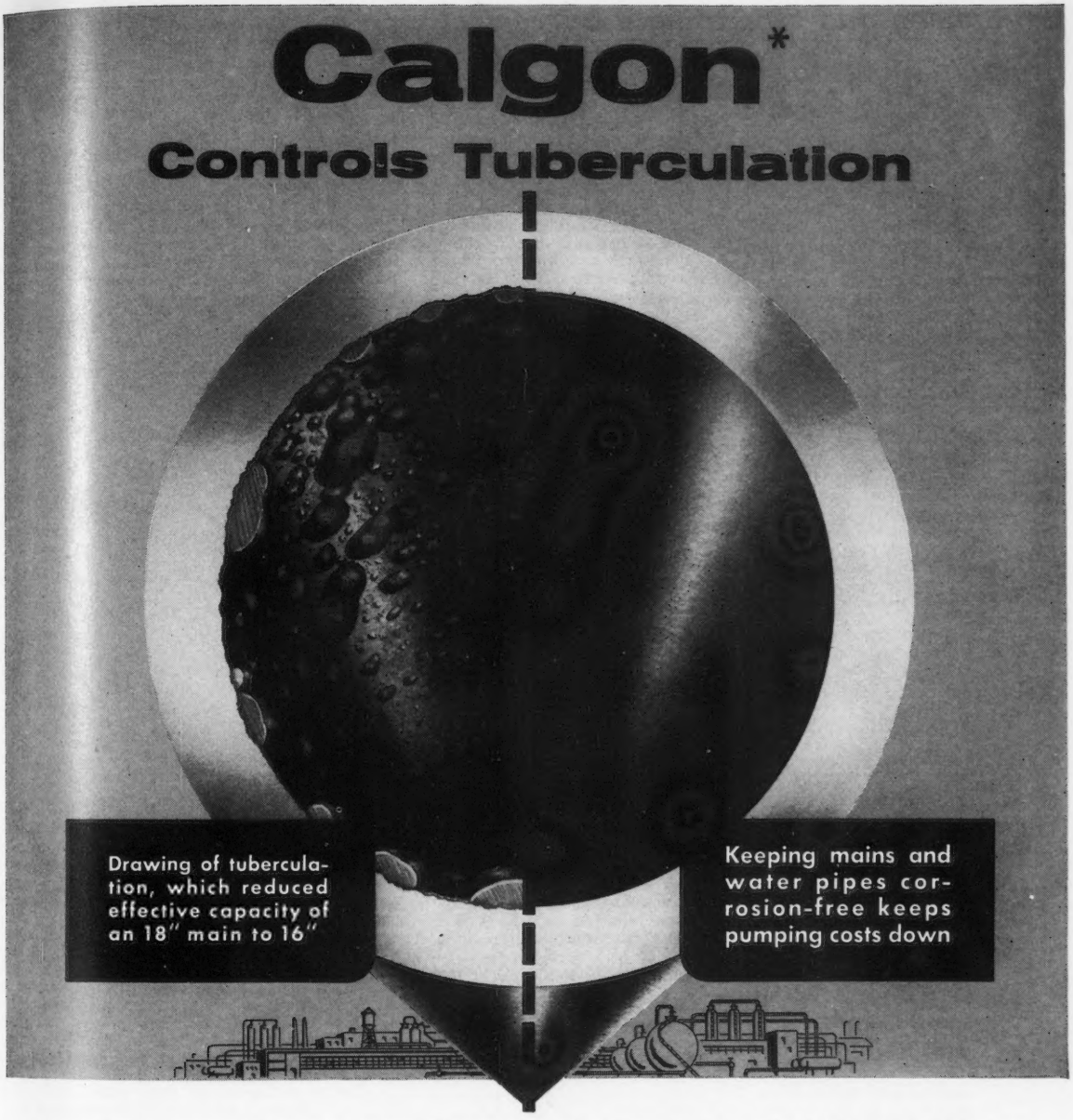
sold at nominal cost to members who desire them. A certificate or plaque to be given to the past officers of sections and regions is under consideration also.

As has been mentioned, the association is issuing in 1954 an NACE Yearbook that will contain the membership directory, a committee directory, the articles of organization and by-laws, a brief history of the NACE, an item on awards given by the association and a brief description of the aims and activities of the technical committees. It is expected this will be completed and ready to send to all members of the association during the summer.

On behalf of the Central Office, permit me to express our appreciation for the cooperation the Central Office has received from the officers, directors, and members. We hope we can continue to serve the NACE to the satisfaction of the membership.

Calgon*

Controls Tuberculation


Drawing of tuberculation, which reduced effective capacity of an 18" main to 16"
Keeping mains and water pipes corrosion-free keeps pumping costs down

avoid damage to cooling and process water systems

Tuberculation in water pipes not only reduces flow drastically, but also adds materially to pumping costs. A case in point is an eastern municipality whose principal raw water supply is carried in an 18" main. Tuberculation reduced the flow in this main from 4.8 mgd to 3.3 mgd within months after each cleaning. The effective diameter of the 18" main had been reduced to 16", and pumping costs were way up.

Corrosion Control with Calgon† was instituted, and the rate of flow held up so well that cleaning costs have been cut by two-thirds. Additional savings of over $40 per day in pumping costs were also realized.

Corrosion and tuberculation run up costs wherever water is used. Calgon Engineering Service can help you keep these excess costs down. Experience with water usage in every type of industry, and a complete grasp of all the pertinent factors is brought to bear on each problem. In each case provision is made to protect the entire system.

Calgon Engineering Service is available to you. Write or phone for the answer to your problem.

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Organizing and Operating a Successful Program of Corrosion Mitigation★

By M. G. MARKLE*

IN THIS DYNAMIC and imperfect economic world there is no single personnel set-up that will fit every organization. However, there are certain fundamental features that can be broadly applied in nearly every case and some significant indications that are too frequently ignored. In addition specific experience and results of the author's company in this field will be cited.

Corrosion mitigation is not a very old activity, at least in terms of current methods and current emphasis. Even so, it is difficult to visualize anyone in a top management position conscious of his own losses due to corrosion who is not reasonably familiar also with the fundamentals of cororsion and the use of cathodic protection. Even *Fortune* magazine, in a recent issue, covered the question pretty well. The writer believes that management in nearly all cases is waiting, maybe unconsciously, but, in effect, waiting to be told what benefits can be derived from a corrosion prevention program and how it can economically be accomplished. The complaint that companies are niggardly in the way they provide for corrosion prevention is a chronic complaint among some who also constantly cry that it is necessary to sell management on its value. It is suggested that what it needed also is an appreciation by the line organization, and, especially, the working organization, that corrosion control is a fundamental. Actually, it is likely that a completely sold and cooperative line organization is more necessary than a convinced management to assure a successful program. It may be a positive danger to have responsibility for corrosion prevention work limited entirely to a staff of specialized personnel, because it may lead to an antagonized line organization that can wreck the whole program.

Management of the writer's company feels that corrosion is everybody's business and so does the line organization. Cooperation received proves the line organization has been sold on the effectiveness of cathodic protection. Both management and the line recognize that it takes specialized personnel with training and information to supply the informed opinion and engineering discretion for the problem.

Lack of Data Biggest Complaint

Management is engaged in a systematic attempt to evaluate experience. It has a good deal of respect for the theoretical causes and the technical methods of preventing corrosion, but is more interested in comparative costs. It wants facts and figures and not just talk as a basis for decisions. Lack of data is management's biggest complaint not the lack of understanding of the problem or its solution.

There is a time factor involved in corrosion that tends to mask the actual causes and costs. This is particularly true of underground facilities. They are hidden where they cannot be observed from day to day and, at most are uncovered only for repairs or additions. Also, their useful life extends over such a long period and through so many changes of personnel, that true maintenance costs and the actual condition of the plant at any particular time are obscure. The frequent tendency and, of course, the easiest procedure is to repeatedly repair and then finally replace without at any time getting to the real cause and solution. It is suspected that a better use of accounting systems to show costs involved in corrosion would make the whole organization more conscious of what is happening to some facilities and permit better evaluation of their true condition. The accounting departments need to be indoctrinated as much as the line organizations.

A point frequently and sadly neglected is that of appreciating managers' and superiors' problems to the end that management can be sold on the need for corrosion control. Keep in mind always that management recognizes its responsibilities not only towards personnel but also for equipment and facilities to make sure they wear out normally, instead of rusting out prematurely. In order to do that management knows it will have to spend a certain amount on maintenance or its equivalent. How this money is spent is where the corrosion engineer comes in. Corrosion engineers should be able to give advice. But recommendations will be listened to much more attentively when due consideration is given to management's viewpoints and goals.

Use Others' Experience

How can this be accomplished? Prof. Irving Lee of Northwestern University says it is not too hard to be a genius. He claims that all that is necessary is to find a genius and observe carefully everything he does and then do the same thing. Now, if that simple procedure produces genius, maybe the same procedure will help convince management of the value of corrosion mitigation and the importance of cathodic protection. Utilize the experience and methods of other organizations that have successfully solved the problem of getting a corrosion control program under way. Establish communications, by one means or another, with individuals directing the corrosion prevention work and apply what is learned to the problem. While there are many effective corrosion set-ups that have sold management on the economics of corrosion prevention yet no two corrosion set-ups are identical. Nevertheless, there are certain basic prinicples which apply in nearly every case. The method reviewed here may start thinking along the right road to a solution.

The writer's employer is a gas and electric utility company serving natural gas to the major portion of the northern part of Illinois, exclusive of the city of Chicago. It has 430,000 gas customers, some of which are supplied by low pressure cast iron mains, as in Oak Park and Evanston but most of the system is served by steel mains. Sometime in 1944, the engineering department became convinced that the application of cathodic protection to new steel mains would be very advantageous. Costs were rising at that time and there was no indication this increase in investment for new facilities would level off in the near future, or return to what was considered normal. Also, plans for a considerable expansion of the system were being made. Those in engineering felt it was necessary to find a means of prolonging life of new gas facilities to offset rising costs and that cathodic protection was the answer. Because the engineering staff had maintained very close contact with management, it was familiar with new plans and the engineers in turn knew and appreciated management's viewpoint.

Investment Per Customer Rising

Engineers knew, for instance, that increased investment per customer was becoming a serious problem and that a major increase in manpower was not favored. The overall policy was to hold the line on personnel. Management was well informed on corrosion problems and the reasons for and the weak points of the specifications in use for pipe coating and methods of protecting miscellaneous underground facilities. No sudden disclosure was made to management about these matters. The subject was kept alive in an informal manner at every opportunity before and during the planning period. Therefore, there was little difficulty in arriving at a complete undersanding of the advantages, economically and otherwise, of cathodically

(Continued on Page 24)

★A lecture delivered at a Short Course on Cathodic Protection, University of Illinois, Urbana, October 12, 1953.

* Gas Engineer, Northern Illinois Gas Co., Bellwood, Ill.

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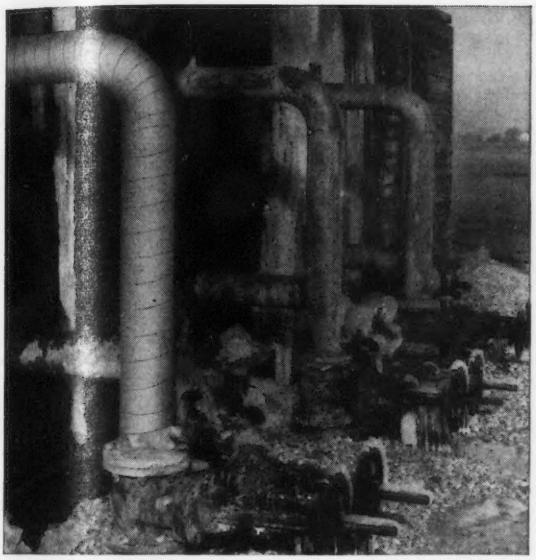
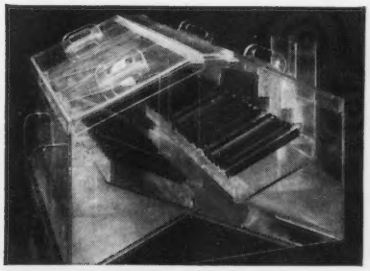
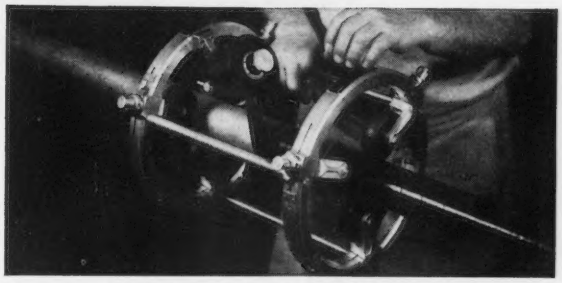


On Michigan-Wisconsin Pipe Line Co. cooling tower, where the temperature is freezing outside and 130° F. inside, the *Polyken* protected pipe on left has outlasted pipes on right 3 to 1 with still no sign of deterioration.



This specially designed spray chamber in the *Polyken* laboratories speeds up corrosion — shows in weeks how *Polyken* will withstand corrosion for years.



Quickly and economically applied. *Polyken* tapes are easily applied either by hand or portable tapester machine as shown here. Tapester wraps, splices, and laps uniformly, and quickly—up to 30 ft. per minute even by inexperienced men.

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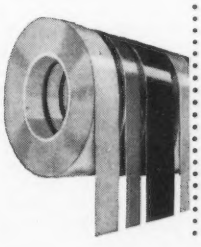

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Organizing and Operating—

(Continued from Page 22)

protecting steel pipe. A general practice of applying cathodic protection in conjunction with continuing the then method of coating and assignment of only one top grade and well-experienced engineer familiar with operating and distribution problems to corrosion work was agreed on.

With only one man assigned to this work it was understood progress would be slow, but this disadvantage was offset by the value of obtaining an early decision to start the program. Actually, this turned out to be the case. There was no delay on the approval and even though only one engineer was working on the project, within fifteen months, all new steel pipe construction was being protected under his direction. In that time standard methods and office routines had been worked out and a series of meetings and group discussions had been held with the line and working organization to gain their support and cooperation. At these meetings the corrosion engineer explained in detail what caused corrosion as found in the field and how he expected, with their help, to prevent it. He made very clear the part that they were to play in the job and how necessary their cooperation was to the success of the program and that his part was to organize the methods so that they would be uniform throughout the company and to locate the cathodic protection facilities for the sake of economy. As a result, the line and the working organization joined whole-heartedly in support of the venture.

As was expected, the work piled up on this single man until he could not carry on alone, but by this time the program was in full swing and making a fine showing, both as to progress and costs, so management was sympathetic to an enlargement of the engineering force.

The Agra Flange Insulation Tester

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A simple device for cathodic protection work designed particularly for personnel installing insulating flanges, swivels, Dressers, etc., so that insulating joints can be left insulating by installer. Uses continuity lamp and compass. Works in manifolds. Uses standard flashlight cells not furnished.

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Unprotected Lines Considered

With cathodic protection being applied as a routine matter to new installations management and engineering became very interested in the possibility of applying cathodic protection to the old unprotected system. There was some 6½ million feet of steel main in service, much of it bare steel and most of it in built-up areas where all other utilities were present. Later, this grew to 18 million feet through merger with another company. Since any gas man's hope is to operate his system without leaks, anything that could be done to approach that ideal was of great interest to all. Also, rising costs made it very desirable to find some way of avoiding replacement of any of this older system. Permission was obtained to make one or two trial installations in areas where observations of results could be made and from these data was worked up a very ambitious program of applying cathodic protection to all of the older system. Protection has been applied subsequently to about 1½ million feet of steel main in the old system, over half of which is on feeder or supply mains rather than on distribution systems within towns.

The greatest difficulty, as expected, was applying protection to steel mains in built-up areas. The difficulty was not in the application and control of cathodic protection but in the small matter of installing an insulating feature on each residential service. The incidental work that accompanies installation of an insulating union within the home resulted in slowing up the program considerably but it is not so discouraging that the goal of providing protection for the whole system has been abandoned.

The corrosion organization of the writer's company is composed of a corrosion engineer assisted by two engineers and one non-technical man with two clerks to take care of the office routines and records. He also has a truck under his direction, fully equipped for all types of cathodic protection work, manned by three men and directed by the non-technical man. This organization engineers and directs all corrosion activities of the gas division of the company.

1082 Miles Protected

In 1952 this organization engineered and arranged for construction of protection for 297 miles of steel distribution mains, ranging in size from 2 to 16 inches in 2500 separate jobs. This required installation of approximately 3400 magnesium anodes. It engineered and installed nine rectifier installations for the protection of existing feeder mains and engineered and arranged for the isolation of and cathodic protection for 180,000 feet of existing distribution main. Total footage of old and new pipe placed under cathodic protection to date is 5,714,000 feet, or 1082 miles.

It also made a complete check of rectifier and anode installation on the major facilities of the system, such as all feeder mains, underground gas storage fields and propane storage tanks buried underground. It directed the work of the corrosion truck and crew which installed about 400 anodes and a large number of insulating flanges and sleeves, as well as rectifiers. It maintained complete records of every installation and field check.

The writer's company does not make extensive field surveys before design but applies a rule of thumb based on experience and knowledge of existing conditions so that the installation will be just adequate or slightly below requirements. Then, when the installation has become stabilized, a field check and corrections are made if necessary. All pipe to be buried is coated regardless of soil conditions with the most economical coal-tar mill-coating. This combination of a standard coating and a minimum of field engineering in advance of construction lends itself very well to distribution work where the jobs are small, numerous and may be installed either by a contractor or company crews.

Surveys Cost Exceeds That of Coatings

Some may feel that this method calls for coating where it isn't needed. The necessary field tests ahead of time to determine the necessity of coating could be made but that would cost more than the coating. As it is corrosion protection, costs are being held to less than 8 percent of investment. This includes engineering costs for corrosion protection, a complete coating job and cathodic protection. The engineering costs on new construction run about ½ of one percent.

This, is one way of doing the job that fits a particular industry and one organization within that industry. It probably will not fit other cases.

It may be more economical to completely engineer the job before installation—just the reverse of procedure related here. It all depends on organization, type, and method of construction—and whether the work is done by company crews or by contract, time available for engineering before construction and, of course, the size of each job. If, for instance, installation of a thousand-mile pipeline was projected the company would without question do considerable engineering on the corrosion problem ahead of construction. Field surveys of soil condition would surely be made and the protection designed to fit. The point is one must be open-minded on the whole problem and attack it from the viewpoint of management as well as from the engineer's viewpoint. Remember that management wants to do the most with the least, whether with men or money.

Engineer Heads Section

Personnel of a corrosion section should always be headed by an engineer, preferable an engineer with considerable company experience in operating or construction, one who has been well schooled in the policies of the organization and capable of entering into discussion with other companies on the question of interference, in an aggressive but congenial and even compromising manner. It has been said that rarely would an engineer fit all of these requirements. However, most engineers, if given the opportunity, will adapt themselves to practically any condition or requirement of a job. Certainly this is true of an engineer that has steadily advanced in the line organization and has had to change his ways to fit himself into each new job. This is the kind of a man and the

(Continued on Page 25)

Organizing and Operating—

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type of engineer needed to lead a corrosion organization.

Provide engineers for engineering work only, supplementing them with non-technical men for routine and footwork. The amount of work that can be taken care of by a bright young lad with only a high school education is always very surprising. Engineers are too hard to get and too expensive to keep, for jobs other than designing, planning and thinking.

Use Line Organization

Remember also that there are definite advantages in utilizing the line and working organizations to carry out certain phases of the work other than that connected with construction. It maintains their interest in corrosion mitigation and intensifies the feeling they are really taking part in the program. This applies to field checks and follow-up procedures after the corrosion prevention facilities are in operation. The author's company's policy is illustrative. The company believes anodes should be checked once the first year and at reasonable intervals thereafter, say eighteen months. Accordingly leads are brought up from each anode and placed in a valve box. With a big program of construction the number of anodes to be checked soon becomes sizable. For instance, the writer's company has 9000 on local distribution mains alone.

Not long after the cathodic protection program was started the problem of checking new installations became important. Continuing checks by the corrosion organization would require more men and cars. Also, there was inherent inefficiency because of travel time to the edges of the gas system. A study of the problem revealed that the job of checking could be done best by the working organization. It had men classified as leak inspectors that traveled the territory surveying for gas leaks. If these men were trained and equipped to take the field readings very little manpower and transportation would be added and the job would be done efficiently. This was done and is working nicely. Again, a chance to build up the department was skipped but much more was gained. First, management was pleased with the solution because there was no buildup of men and transportation, and second, line and working organizations' interest was increased by having a chance to see the results of cathodic protection.

To summarize:

1) Management is enlightened, but needs facts and figures to make a decision. It knows what cathodic protection is, but is waiting to be told how to apply it.
2) Get into management's shoes to obtain its viewpoint. This is a hard to do but very, very necessary.
3) Maintain good communications with superiors so that complete mutual understanding of problems is established.
4) Don't be impatient. Corrosion has been at work since time eternal and it can't be stopped in a day.
5) By all means, sell the line and working organizations.
6) Spread the work as much as possible and maintain a minimum central organization.

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NEW PRODUCTS —Materials—Service—Literature

Titanium Metals Corp. of America, Henderson, Nevada has developed a 20-ton automatic double-melting furnace of proprietary design said to completely remelt 4000-pound titanium ingots with improved metal homogeneity. The new melting process is said to permit removal of hydrogen to as low as 50 parts per million.

•

Tube-Kote, Inc., P. O. Box 20037, Houston, Texas has installed an electronically controlled plastic extrusion machine as part of the initial $100,000 worth of equipment that the company is using to equip its new plastic pipe manufacturing division.

•

Fatigue Properties of sheet stock as thin as 0.010-inch are said to be measurable on the Sonntag SF-2-U fatigue testing machine, manufactured by Baldwin-Lima-Hamilton Corp., Philadelphia, Pa. Machine capacity is 50 pounds with amplifying fixture and maximum deflection is ½ inch.

•

Erkote 6X Weather Barrier, a mastic designed for use over thermal insulation of heated equipment permits drying out of rigid insulation when equipment is brought up to operating temperatures. It expands and contracts with the equipment. It contains no water, and is not corrosive to bindings the company, Earl Paint Corp., 240 Genessee St., Utica, New York says.

•

Thermo-Cote K, a transparent butyrate base plastic applied at 300 degrees F to surfaces and edges of metal tools and parts protects them against corrosion and abrasion in storage, manufacturers, Bischoff Chemical Corp., Ivoryton, Conn. claims. It is said to have none of the oil exudation common to thermoplastic coatings and is quickly removable by slitting and peeling, and may be re-used.

•

MSA ChemKlos, special protective work clothing submitted to atmospheres containing caustic dusts, vapors and liquids, showed no deterioration. Mine Safety Appliances Company, Pittsburgh is manufacturer.

•

Protective Coatings by Ceilcote, Catalog C-150 is available from Ceilcote Company on letterhead request addressed to 4874 Ridge Road, Cleveland, Ohio. Information is included on the company's industrial paints covering formulation, temperature resistance, abrasion resistance, chemical properties, adhesion, application, surface preparation and colors.

•

Norelco MG 60 fluoroscopy and radiography unit for x-ray examination of light metals, rubber, porcelain, plastics and glass weighs 46 lbs. It is made by Research and Control Instruments Div., North American Phillips Co., Inc., 750 South Fulton Ave., Mount Vernon, N. Y.

•

Polyclad Protective Coatings, a bulletin about polyvinyl chloride copolymer coatings is available from Carboline Company, 331 Thornton Ave., St. Louis 19, Mo. General properties of the coatings are given and a table of primer data for various surfaces is included.

•

Cupola Dust Control systems, including washing, dry suction cyclone, combination gas conditioner and suction bag are covered in Bulletin No. 3 available from Mechanical Industries, Inc., 942 Grogan Bldg., Pittsburgh 22, Pa.

•

C-Oil, a new chemical derived from oil expected to be used as a raw material in many products, including paints with high resistance to chemicals has been developed by Standard Oil Development Co. Glidden Company has been licensed to develop surface coating uses for the new petrochemical. Products so far produced experimentally include metal primers and glass-like plastics which can be machined almost like metal. The material is being produced in experimental quantities by the Esso Laboratories, Baton Rouge, La. In the coatings field the material is expected to reduce reliance of the coatings industry on such products as linseed, soya, tung and other agricultural oils. Bonding to metal may be two to three times better than some other plastics.

•

Kaiser Aluminum and Chemical Corp. at Trentwood, Wash. has begun a $1,-500,000 expansion of aluminum sheet rolling and finishing facilities. Major additions will be two rolling mills, a 3000-foot-per-minute cold rolling mill designed to produce light-gauge sheet and a mill to produce wide embossed, or patterned, sheet.

•

Silastic S-2007, a silicone rubber developed by Dow Corning Corporation, Midland, Mich., is a resilient dielectric coating material for extreme temperature electric and electronic components which cures in 2 to 4 hours at 200 degrees C to form a jacket which is uniform, heat-stable, moisture proof and highly resistant to oxidation, ozone and weathering.

•

Ferro Enamels (Proprietary) Ltd. (Ferro, South Africa), a subsidiary of Ferro Corporation, will construct a porcelain enamel frit-producing factory in Brakpan, Transvaal, South Africa. W. Massey will be the new managing director of Ferro-South Africa.

•

Benzyl Mercaptan, a new product that may be used as a corrosion inhibitor in the production of petroleum products, as a softening agent for Thiokol polysulfide polymers to obtain soft rubbers or as an organic intermediate to introduce benzyl sulfide groups into the structure of organic compounds is the subject of a product bulletin available on request from Thiokol Chemical Corp., 780 N. Clinton Ave., Trenton, N. J.

•

A New 20-Page booklet issued by American Agile Corp., P. O. Box 168, Bedford, Ohio includes information on the chemical resistance of three thermoplastic construction materials, Agilene (polyethylene), Agilide (nonplasticized PVC) and Agilux (high impact PVC) at various working temperatures. The piping section includes data on pipe, fittings, tubing, valves and ducting components constructed of the new materials.

•

Permanite, a thermosetting furfuryl alcohol resin available in almost any shape from valves to large towers, is said to be corrosion-resistant. It will handle most acids, oils, alkalies and organic solvents at high temperatures and is lightweight, strong and shock resistant. Bulletins describing equipment made with this material are available from Maurice A. Knight, Kelly Ave., Akron, Ohio.

•

International Nickel Co. of Canada is building a $16,000,000 plant near Copper Cliff, Ontario to have the tallest chimney in the British Commonwealth—615 feet high. The plant will recover high-grade by-product iron ore from nickel ores mined in the Sudbury District.

•

A New Line of Stavolt DC Power Rectifiers is being produced by McColpin-Christie Corp., Los Angeles. The C&C units are regulated by a magnetic amplifier control of stable and permanent qualities. No tubes, lamps, carbon piles or varistors are used.

•

A six month test under operating conditions and involving 4000 hours of continuous service has indicated that ceramic coated steel tubes can reduce operating costs and maintenance problems of air preheater tubes in power plants, according to Report No. 3954, A Report on Barrows Glass Lined Process Tubing and Report No. 454, A Performance Report on Vitralloy Air Preheater Tubes. The reports have been issued by Barrows Porcelain Enamel Co., Cincinnati, Ohio and are available on request.

From inspection and analysis of the tubes used in the test it was determined that the two primary problems that exist in air preheater use are clogging and corrosion which start at the cold end and progress to near the mid-point of the heater. Ceramic coated tubes will reduce this damage, the report states.

Major conclusion of the test is that Vitralloy tubes, in spite of a comparatively higher initial cost, can increase efficiency and decrease maintenance problems of air preheaters.

•

Tubular Products Division of the Babcock & Wilcox Co., 161 E. 42 St., New York City has completed an expansion program which will increase by nearly 40 percent its productive capacity for stainless steel tubular products.

•

Pittsburgh Corning Corp. furnished the insulating material for the huge sphere built by the Atomic Energy Commission and General Electric Co. to test an atomic submarine engine. The 225-foot sphere was insulated with Foamglas, a cellular glass material impervious to moisture. This material also had excellent heat retaining qualities and will help to maintain constant interior pressure and temperature.

NEW PRODUCTS

A bulletin describing Asarcon Continuous-Cast bearing bronze (SAE 660) is available on request from Continuous-Cast Products Department, American Smelting and Refining Co., Barber Station, Perth Amboy, N. J. The bulletin also describes the Continuous-Cast Process by which bronze alloys are cast into rods, tubes and shapes of different diameters and profiles.

•

The First Section of a 24-page booklet issued by Alcoa gives an explanation of the corrosion protection provided by cladding on Alcoa heat exchanger tubes of all types. Alcoa Aluminum Heat Exchanger Tubes is the title of the booklet, latest in the Aluminum Company of America technical booklet series.

•

A Norelco magnetic-particle test unit called Portaflux that weighs 45 pounds has been developed by the Research & Control Instruments Div., North American Philips Co., Inc., 750 South Fulton Ave., Mount Vernon, N. Y. The unit is designed to locate surface defects in rough castings, bar stock, forgings and shop welds.

•

American Wheelabrator & Equipment Corp., Mishawaka, Ind. is producing a new airless abrasive blasting machine for the reconditioning cleaning of 30 and 55 gallon steel drums before painting and coating operations. The machine is said to be capable of cleaning the exterior surfaces of closed-end drums and both the exterior and interior surfaces of open-end drums, together with the lids.

•

Visco Products Co., 2600 Nottingham, P. O. Box 6826, Houston, has issued a free bulletin in commemoration of its 25th anniversary. The bulletin describes the organization of the company and the chemicals produced. Some of these are used in corrosion control, scale control, paraffin control, emulsion breaking and desalting.

•

Sonntag Model SF-4 fatigue machine of 13,000-pound capacity is described in a bulletin, No. 4214, by Baldwin-Lima-Hamilton Corp., Philadephia. Elevated temperature testing, principles of "constant-force" operation and specifications are included.

•

Ferro Corporation has purchased the Louthan Manufacturing Co., East Liverpool, O., from Harbison-Walker Refractories Co., Pittsburgh, Pa. The new Louthan Division will produce electrical porcelain insulators, refractory specialties for firming pottery and for the foundry field and other ceramic products. Harry T. Marks will be the new president of the Louthan Division and Charles W. Gerster will be executive vice-president and general manager.

•

A Bakelite vinyl resin-base coating that can be applied by spray, brush or roller is said to make masonry surfaces more durable, decorative and economical to maintain. These coatings are said to withstand weathering and abrasion, resist moisture, chipping and peeling. The coating is available from Bakelite Co., a Division of Union Carbide and Carbon Corp., 260 Madison Ave., New York City.

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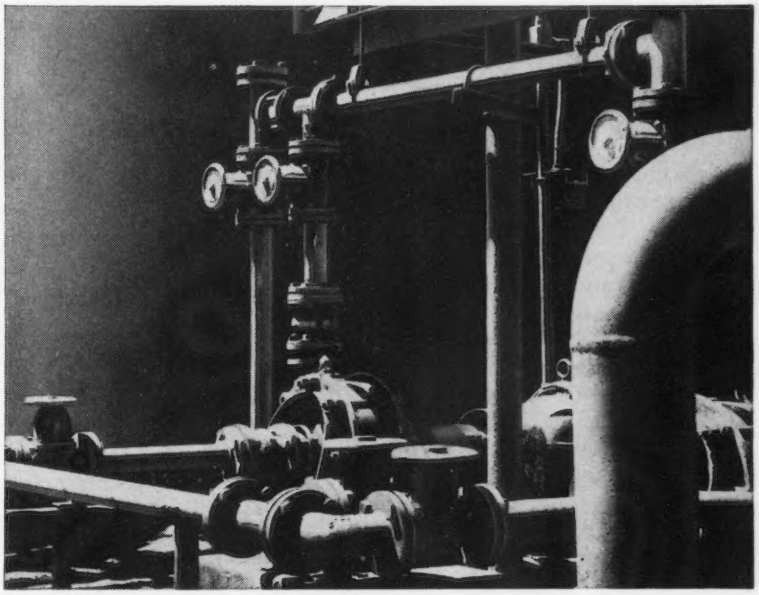

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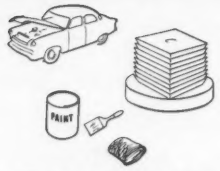

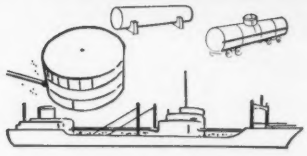

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Corrosion Abstracts

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CORROSION

for announcement about the 1948-49 Bibliographic Survey of Corrosion and the special combination prices for sets of two and three volumes of the bibliography.

If you have corrosion problems you need the Bibliographic Surveys.

1. GENERAL

1.2 Importance

1.2.2, 1.7.2

The Battle Against Decay. *Fortune,* **47,** No. 2, 148-151+ (1953).

The fight against rust costs the U. S. at least $6 billion a year. The nature of corrosion and some methods for combating it are illustrated. A quantitative study of corrosion is carried out at Inco's Kure Beach test station, where test racks hold specimens for assaying corrosion to sea air, sea water and marine fouling.—INCO. 6340

1.2.5, 5.4.5

The Ignition of Inflammable Gases by Sparks from Aluminium Paint and Rusty Steel. F. E. T. KINGMAN, E. H. COLEMAN AND Z. W. ROGOWSKI. *J. Applied Chem.,* **2,** No. 8, 449-456 (1952).

The conditions under which sparking owing to the initiation, by striking, of a thermite reaction between aluminum paint and rusty steel might constitute an explosion hazard are investigated and the possibility of reducing the hazard by variation of the nature of the paint vehicle is considered. None of the commercial types of paint examined gave incendive sparking unless the specimen had been preheated, but the critical preheat temperature varied with different paints, being relatively low in the case of cellulose nitrate paint, which, it is considered, should not be used where explosive concentrations of gases or vapors may be present. In an appended note on the practical application of the results, S. H. Wilkes considers that aluminum paint may be used on iron, but recommends the following precautionary exceptions: 1) aluminum paints with a cellulose nitrate base should not be used in inflammable atmospheres, and 2) no aluminum paint, whatever its base, should be used in such atmospheres if the paint is likely to be heated to 150 degrees C. Use of a paint under conditions contrary to these recommendations might be safe in some cases, but should be preceded by tests similar to those described by Kingman, Coleman and Rogowski.—MA. 6755

1.5 Directories of Material

1.5

Corrosion Charts Analyzed. F. L. LAQUE. Inco, *Chem. Eng.,* **59,** No. 9, 264, 266-268, 270-272 (1952) Sept.

Points out the difficulties and dangers involved in the new series of charts showing corrosion data for specific materials of construction vs. a number of corrosives.—INCO. 6772

1.7 Organized Studies of Corrosion

1.7.3, 5.4.5

Corrosion. M. G. FONTANA. *Ind. and Eng. Chem.,* **45,** No. 8, 91A-93A (1953) Aug.

Discusses the use of the custom testing service of Kenneth Tator Associates available to manufacturers of protective coatings. This corrosion test service is based largely on the successful experience of the KTA test panel which has shown good correlation with actual service experience. Diagram.—INCO. 6316

2. TESTING

2.2 On Location Tests

2.2.2

Outdoor Exposure Testing on Racks and Test Fences. K. G. COMPTON. *ASTM Bull.,* No. 182, 23 (1952).

A description is given of the physical structure of outdoor exposure racks and test fences and the principal factors to consider in their location. A concensus of experience is given as to the effect of the direction which the specimens face and the angularity with respect to the horizontal plane. Further discussion is given as to the effect of the location of the specimens with respect to nearness to ground, sheltering from wind, the top of buildings, proximity to industrial contamination, etc. The influence of geographical location is also discussed, whether in dry atmosphere, exposed to bright sunlight, to an atmosphere contaminated by the fumes from industrial plants or by salt from ocean spray. A discussion of climatology is included which

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brings out the effect of sun, rain, condensation or dew, relative humidity and cycling of humidity and temperature. The author attempts to show the influence of these various factors upon the probable results of outdoor exposure testing as an explanation for the many conditions imposed in ASTM tests of this nature.—RPI. 6746

2.3 Laboratory Methods and Tests

2.3.4, 6.2.5

Contamination of Nitric Acid as a Source of Error in the Huey Boiling Nitric Acid Test. ROBERT J. BENDURE. *Corrosion* (News Sec.), **10,** No 3, 1 (1954) Mar.

Erratic results obtained in testing austenitic type stainless steels were found to be the result of contamination by fluorides which followed use of laboratory equipment for tests involving hydroflouric acid. Erratic rates in another laboratory were found to be the result of contamination by hydrogen sulfides from experiments conducted in adjacent areas. 6669

2.3.5

Corrosion Testing by Measurement of Local Cell Potentials. J. K. RICE. *Corrosion,* **10,** No 1, 25-29 (1954) Jan.

The method of studying corrosion rates by measuring the local cell potential using a rotating electrode and stationary microprobe reference electrode is briefly reviewed. The results are presented of applying the method to the study of the effect of different variables on the corrosion inhibition properties of hexametaphosphate on steel in aerated water systems. 6723

2.3.5, 4.5.1, 2.4.2, 2.1.1

Laboratory Measurement of the Corrosion of Ferrous Metals in Soils: Research Paper 2422. W. J. SCHWERDTFEGER. *J. Research Nat'l. Bureau of Standards,* **50,** No. 6, 329-336 (1953) June. *Corrosion,* **10,** No. 1, 30-36 (1954) Jan.

Method for setting up soil-corrosion cells using a soil-wetting procedure that gives reproducible results. Cell has 2 stainless steel screens which help to insure good contact of the soil with the electrodes. By measuring weight losses on cell electrodes made of steel and cast iron after exposure to various soils for 6 months, the effects of corrosion on the 2 materials could be compared. The electrode weight losses correlated with the weight losses and maximum pitting on wrought ferrous specimens exposed for 10 years at the field test sites. Because the laboratory soils covered the range of corrosivity peculiar to soils, empirical equations for predicting weight loss and pitting at the end of 10 years, presumably for any soil, could be derived. Reasonable adjustments can be made for areas other than that of the field specimens and for exposure periods other than 10 years. Appendix discussed preparation of the corrosion cell. Tables, 12 references.—INCO. 6533

2.3.5, 2.4.2

The Measurement of Electrode Potentials. NORMAN HACKERMAN. *Corrosion,* **10,** No. 2, 70-72 (1954) Feb.

A few half cells of interest in corrosion measurements are described in terms of their preparation and use. Brief descriptions of potential measuring devices and their principles of operation are also given. 6748

2.3.6, 2.6

The Examination of Metal Surfaces by Means of the Electron Microscope. I. Technique of Preparation. (In Dutch). V. CH. DALITZ AND J. A. SCHUCHMANN. *Metalen,* **7,** No. 9, 153-161 (1952).

A detailed description of a method developed by Dalitz and Schuchmann. An etched metal is placed in a vacuum belljar and a thick silver layer evaporated upon it. The negative silver replica is then vacuum-coated with a thin film of silicon oxide and the silver side brought into contact with a 40 percent nitric acid solution. After the silver has been dissolved, the positive replica is shadow-treated. Another method is the polymerization of a hydrocarbon film on the silver replica, instead of silicon oxide. The silver silicon oxide or silver/hydrocarbon method may be used for such metals and alloys as steel, copper, platinum, aluminum, brass, bronze and bearing metal. 7 references.—MA. 6725

2.3.6, 6.4.2

An Etching Agent Revealing Segregation in Aluminum Alloys. (In French). CHARLOTTE BUCKLE, CHRISTIANE CHANGARNIER AND JEAN CALVET. *Compt. Rend.,* **235,** 1040-1041 (1952) Nov. 3.

Proposes an aqueous solution of 4 percent potassium permanganate and 2 percent soda for aluminum-magnesium, aluminum-copper, aluminum-silicon, aluminum-manganese, aluminum-chromium and aluminum-titanium alloys. Techniques and results are given.—BTR. 6791

2.3.7, 5.3.2, 5.3.4

Methods of Testing Nickel-Plating Baths and Nickel Coatings. J. ELZE. *Metall,* **6,** No. 1/2, 5-11 (1952).

Recommended methods for carrying out the following tests are discussed at some length. For nickel coatings: 1) adhesion, 2) porosity, 3) hardness, 4) crystal structure, 5) suitability for any subsequent chromium plating, 6) corrosion protection of the basis metal, 7) internal stresses, 8) suitability for subsequent polishing, 9) brightness, 10) flatness, 11) metallographic cross-section, and 12) influence of pretreatment on the plating quality of the basis metal. For nickel baths: 1) the effects of surface-active agents in rapid baths and 2) current distribution; in addition the following routine tests are necessary: 3) pH, 4) chemical analysis, 5) specific gavity, 6) voltage and 7) turbidity—in regard to the efficiency of filtration. 12 references. —MA. 6754

2.4 Instrumentation

2.4.2, 2.3.5

Electrochemical Phenomena at a Rotating Mercury Electrode. I.—Reduction of Metal Ions. T. S. LEE. *J. Am. Chem. Soc.,* **74,** No. 20, 5001-5008 (1952).

A rotating-mercury electrode which combines the advantages of dropping mercury and rotating-platinum electrodes in analytical work and physico-chemical studies is described and illustrated. With the apparatus, the diffusion current of metal ions was found to be strictly proportional to concentration in the range 10^{-4}-10^{-7} M, and the half-wave potential of a given metal ion (cadmium) was independent of concentration over the same range. Derived equations for other relationships are presented and discussed. The apparatus is useful for the analysis of electro-reducible substances at very low concentrations in aqueous solution. —MA. 6702

2.4.2, 2.2.8, 7.1, 8.7.2

The Measurement of Gas Temperature by Immersion-Type Instruments. E. F. FLOCK AND A. I. DAHL. Natl. Bur. Standards. *J. Am. Rocket Soc.,* **23,** No. 3, 155-164 (1953) May-June.

Methods and instruments for measuring the temperatures of gases in turbines and jet engines by means of sensing elements immersed in the working medium are reviewed. Immersed instruments must withstand attack by compounds of sulfur, lead and possibly vanadium. The most widely used base metal thermoelements, Chromel and Alumel, as well as the platinum metals, have adeuate resistance to oxidation and reduction. Diagrams, graphs and 18 references.—INCO. 6307

2.4.3

Ultrasonic Inspection Checks Quality of Brazed Joints. H. GREENBERG. *Materials and Methods,* **35,** No. 6, 102-105 (1952).

The ultrasonic testing of brazed joints between Cupaloy (i.e. an age-hardening alloy containing copper 99.5 percent, and chromium 0.5 percent) and a contact alloy (i.e. tungsten 65 percent and silver 35 percent) is discussed and the close correlation between ultrasonic testing and destructive shear testing illustrated. The advantages and disadvantages of ultrasonic methods for testing rotors, thrust-bearing shoes, turbine discs and miscellaneous forgings of all types are given.—MA. 6773

2.4.3

Non-Destructive Measurements of the Thickness of Non-Metallic and Metallic Surface Layers. F. FORSTER. *Metall,* **7,** No. 9-10, 320-324 (1953) May.

Various methods of non-destructive measurement and their fields of application are discussed. The four main types of electrical instruments described are the Isometer, Argentometer, the precision thickness meter and the nickel thickness meter. The nickel meter is an American development and is applicable to the measurement of nickel deposits on base metals. Its principles are detailed.—INCO. 6319

2.4.3, 8.9.3, 3.2.2

Detecting Internal Corrosion by Ultrasonic Inspection. D. C. ERDMAN. Electro Circuits, Inc. *Gas,* **29,** No. 7, 104, 106 (1953) July.

Detection of pit type corrosion in pipelines by ultrasonic inspection is discussed. A probing beam diameter of ⅛-inch gives satisfactory detail as to the thickness of metal directly over the pit.—INCO. 6333

2.5 Specifications and Standardization

2.5, 2.3.2

Analysis of Variability in Accelerated Corrosion Testing Cabinets. V. V. KENDALL. U. S. Steel Corp. Paper before AISI, Gen. Mtg., N. Y., May 27-28, 1953. Am. Iron Steel Inst., Preprint, 1953, 19 pp.

Results of the work of the AISI Tech. Comm. on Protective Coatings on a study of the reproducibility obtainable in spray or humidity test cabinets are pre-

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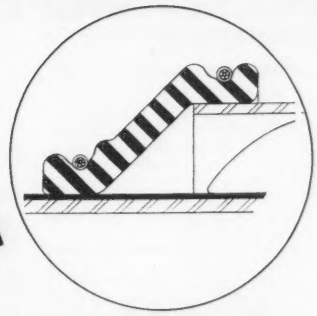

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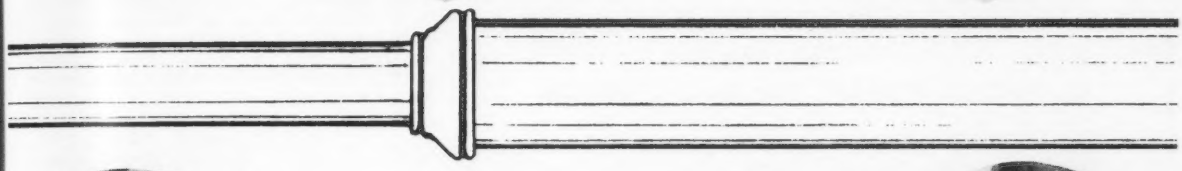

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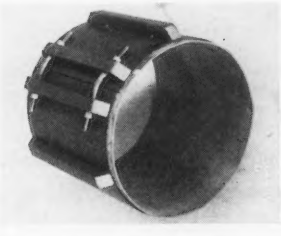

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3. CHARACTERISTIC CORROSION PHENOMENA

3.2 Forms

3.2.2, 1.3

Hydrogen Embrittlement & Hair-Line Cracks in Steels. A. B. CHATTERJEA AND B. R. NIJHAWAN. *J. Sci. Ind. Research*, **11A**, 158-161 (1952) Apr.

Literature review. 45 references.—MR. 6744

3.2.2, 5.9.2

Hydrogen Diffusion in the Pickling of Spring Steel. J. S. JACKSON. *J. Electrodepositors' Tech. Soc.*, **28**, 89-101 (1952).

Atomic hydrogen released during pickling, electroplating or cathodic degreasing treatments is known to diffuse rapidly through the iron lattice in which it may be absorbed. It recombines at discontinuities in the lattice to form molecular hydrogen which may become entrapped at high pressures, since molecular hydrogen cannot diffuse out of the steel in the same way. The exact mechanism of embrittlement is not certain, but the susceptibility of steel to embrittlement increases rapidly with increase in carbon content up to 0.7 percent. Low temperature heat treatment, even before plating, is not very satisfactory and after plating the deposit may prevent the escape of gas. It is preferable to adopt the special pickling treatments recommended by the Coil Spring Federation.—ZDA. 6668

3.2.3, 6.3.10, 3.7.2

Oxide Film on Nickel-Chromium Alloys—Crystal Structure Studies. E. A. GULBRANSEN AND W. R. MCMILLAN. Westinghouse Res. Labs. Paper before ACS, 123 Mtg., Los Angeles, 1953. *Ind. and Eng. Chem.*, **45**, No. 8, 1734-1744 (1953) Aug.

Crystal structure studies were made on 8 alloys of the nominal 80% nickel-20% chromium composition using electron diffraction methods. The silicon and manganese compositions of these alloys were varied in a systematic way. Alloys were oxidized over a temperature range of 400-950 degrees C. Electron diffraction patterns were used to study the effect of time and temperature on the crystal structure as the oxide formed on the alloy. Crystal structure information was correlated with the composition of the alloy and with its useful life in high temperature cyclic oxidation tests. Nickel oxide is found at 400 degrees and 500 degrees C for short oxidation periods and chromic oxide for long oxidation periods. Tables, graphs and 30 references.—INCO. 6335

3.2.3, 3.7.2, 6.3.10, 6.3.15, 4.3.3

Influence of Alloy Elements and of Treatment With Metal Oxide Vapours on Rate of Oxidation of Nickel and Titanium. H. PFEIFFER AND K. HAUFFE. *Z. Metallkunde*, **43**, No. 10, 364-369 (1952) Oct.

Data on effects of addition of 0.1, 0.3, 0.5, 1.0 atomic percent chromium and of 0.1, 0.3, 0.7, 1.0 atomic percent silver to pure nickel. Oxidation of nickel in oxygen and in oxygen + lithium oxide vapor showed that resistance was increased by lithium oxide. Titanium treated with tungsten trioxide showed improved resistance. Possible influence of oxide vapors on growth of oxide films is dealt with. Various other vapors discussed include tungsten oxide (on nickel), aluminum oxide, molybdenum dioxide, molybdenum dioxide, molybdenum trioxide.—INCO. 6341

3.2.3, 6.4.2, 3.8.4

Aluminium Oxide Films. A. CHARLESBY. Ministry of Supply, Harwell, Berks, England. Atomic Energy Research Establishment, Unclassified C/R 861, 40-42, 1952.

When aluminum foil is anodized at constant current in ammonium borate electrolyte, the voltage increases as the oxide-film thickness increases. As it is impossible to exceed 500-700 v owing to electric breakdown, there is a limiting film thickness at room temperature. The ratio of the formation voltage to film thickness is about 10^7 v/cm at room temperature and is independent of formation voltage up to several hundred volts. At higher temperatures smaller fields are required. Above about 200-300 degrees C film growth can continue indefinitely at a finite rate. Mott's ideas on the oxidation in air of metals such as aluminum are applied to these anodized

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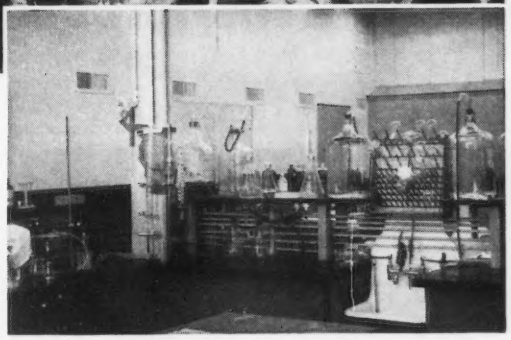
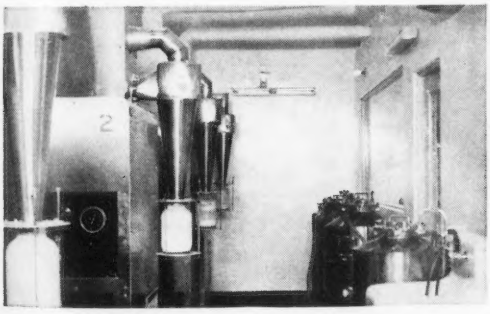
"Going strong after 2 years . . ."

RESISTS ACID (right). In this processing area of the R. K. Laros Co., fermentation, hydrolysis and fractionation of dextran takes place. Sanitary requirements mean constant washings of the room with strong detergent solutions. Alcohol and hydrochloric acid fumes are always present. Wooden ceiling, brick side walls, floor and all metal work except stainless steel are protected with same A&A Parlon-based finishes. Protective coating applied in 1952 is still in excellent condition.

RESISTS ALKALI (below). This spray-drying room, Chemical Division, R. K. Laros Co., still has a "just painted" look after two years. A&A Parlon-based paint, manufactured by Barreled Sunlight Paint Co., Providence, R. I., was put on over fresh plaster on walls and ceilings. It has resisted alkali in the plaster from underneath, frequent washings with a germicidal solution from without.





STAYS SANITARY (above). R. K. Laros Co. laboratory remains attractive and clean after two years service from A&A Parlon-based finish. Plaster and brick areas, wooden cabinets and metal grilles were all painted with the same finish and have resisted cumulative attacks of chemical and acid fumes.

Paint based on Hercules Parlon (chlorinated rubber) has been taking a beating for two years on all types of surfaces and under a variety of chemical conditions at the R. K. Laros Company plant in Bethlehem, Pa. Yet it still looks clean, sanitary, and fresh; and retains its original decorator colors.

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oxide films. In order to obtain agreement with experimental data, the author generalizes these ideas to include an electron, as well as an ion, current in the film.—ALL. 6672

3.5 Physical and Mechanical Effects

3.5.6, 3.2.2, 2.3.7

Some Notes on Hydrogen Blistering—a Technical Note. *Corrosion,* **10,** No. 3, 101-102 (1954) March.

Data were obtained on the diffusion of atomic hydrogen through several kinds of steel in acidic solutions. Where diffusion occurred, the presence of sulfide increased the diffusion rate. In an electric furnace grade steel, diffusion did not take place unless sulfide was present. Observations were made on the permanence of the sulfide surface associated with rapid atomic hydrogen diffusion. 6670

3.5.8

Metal Transfer and Wear. I.—Ming Feng. Ph.D. Thesis, U. Mich. *J. Applied Phys.,* **23,** 1011-1019 (1952) Sept.

A new theory of metal transfer and wear is suggested. The mechanical interlocking of roughened surfaces of high spots causes breakage below this interface on the application of a tangential force. A weld spot may be formed from the heat flash during breaking. Otherwise a loose wear particle is formed. The effect of surface contamination is discussed. 6774

TK-2 SOLVES PIPE CORROSION AND PARAFFIN PROBLEMS

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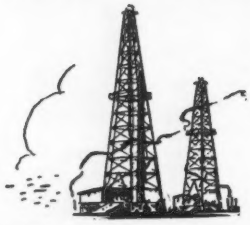
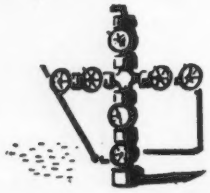
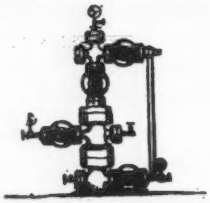


DRILL PIPE — Uncoated steel pipe used in a West Texas field failed because of corrosion after drilling only 5,000 feet. Drill pipe lined with TK-2 and used in same field has drilled to 70,000 feet without failure.



HIGH PRESSURE OIL WELLS—In wells where excessive carbon dioxide has been encountered, uncoated pipe has failed because of corrosion in 10 to 18 months. Pipe lined with TK-2 used in same wells showed no signs of corrosion even after 28 months.



GAS LIFT WELLS — Uncoated pipe installed in one field in 1949 failed because of corrosion after 2 years. Pipe lined with TK-2 used in same field is still in good condition after 5 years!

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3.5.8

On the Limit of Corrosion Fatigue. G. V. Karpenko. *Doklad. Akad. Nauk,* SSSR, **87,** No. 4, 617-620 (1952).

Represents attempt to fill gap in problem of behavior of fatigue occurring in respect of corrosion-active media and to establish whether there exists a corrosion-fatigue limit. Experiments were on steels (compositions not indicated). Results are given.—INCO. 6804

3.5.8

Fretting Corrosion—What It Is, Its Cause and Possible Preventives. A. H. Allen. *Metal Progress,* **62,** No. 6, 71-76 (1952) Dec.

Examination of Douglas Godfrey and Edmond E. Bisson's work on fretting. Mild, chromium and stainless steels, copper, aluminum and SAE 52100 steel were used for the experiments. Evidence indicates that fretting is caused, not by oxidation, but by the loosening, due to inherent adhesive forces, of finely divided and evidently virgin material. On most metals this material oxidizes rapidly as it is extruded from the contact area. Effectiveness of molybdenum disulfide as an inhibitor appears promising. Photomicrographs of fretting on chromium steel balls are included.—INCO. 6710

3.5.8

Fretting as a Chemical-Mechanical Process. K. Dies. *Technische Mitteilungen Krupp, Forschungsberichte,* **5,** No. 10, 127-140 (1942) Apr; *J. Iron Steel Inst.,* **172,** Pt. 2, 251 (1952) Oct.

Wear experiments on numerous friction pairs indicated that the appearance of frictional oxidation is not always immediately dependent on their hardness, but chiefly on the hardness and adhesion properties of the products of friction. X-ray and analytical methods indicated the formation of very hard corundum by the rubbing of aluminum. This hard material would then attack the parent substance. A high attacking ability was shown by austenitic stainless steel. Copper and zinc show a favorable behavior. In the absence of oxygen, no oxidation could take place.—INCO. 6698

3.5.8, 3.2.2

Cracking of Ferrous Materials as a Result of Combined Corrosion and Mechanical Stresses. E. Herzog. Paper before Semaine d'Etude de la Physique des Metaux, 1951. *Metaux: Corrosion Industries,* **27,** No. 325, 329-357 (1952) Sept.

Deals with rupture through combined effects of corrosion and mechanical stress (static) and with rupture through combined effects of corrosion and dynamic stress. Examination was made of effects produced by corrosion alone, by stress alone and by combined stress and corrosion. Nature and mechanism of the various forms of attack and intercrystalline failure through corrosion-fatigue are discussed. Testing methods and equipment are surveyed and evaluated. Sections include effects of heat treatment, cooling rate above and below transformation point, hot-rolling and decarburization. Original work by Herzog and others includes reference to nickel-chromium-molybdenum steels which showed transcrystalline cracking in dilute hydrocyanic acid and to effects of heat-treatment on on corrosion-resistance of steel containing 0.25% carbon, 17% chromium, 1.5% nickel. Extensive section on stress-corrosion-cracking of austenitic steels is

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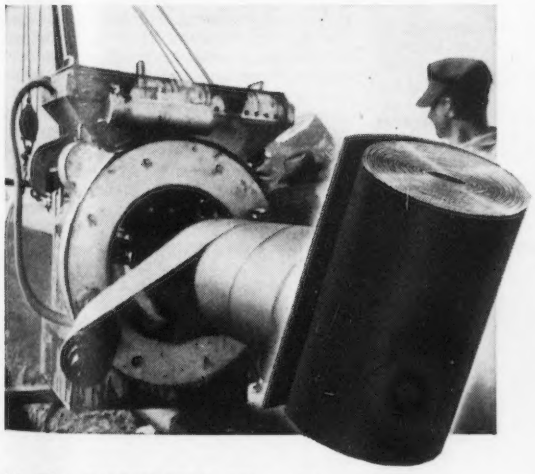

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given. Effects of plastic deformation on behavior of 18/8, notes on results of variation in carbon, chromium and nickel contents of austenitic steels, data on susceptibility to cracking and corrosion-cracking in 18/8 as a function of nickel content, degree of cold-work and heat-treatment and experiments on corrosion-fatigue of carbon and nickel steels (apparently in aqueous and saline media) are described.—INCO. 6693

3.5.8, 3.7.4

Intercrystalline Cracking of Metals. J. NEILL GREENWOOD. *J. Inst. Metals* (Englang) *Bull.*, **1,** Part 12, 104-105 (1952) Aug.

Letter to the editor: It is postulated that in crystals even of an annealed metal many vacant lattice sites exist and that under the joint action of stress and thermal movement of the atoms these vacant sites can migrate. In the higher-melting-point metals this may need an elevation of temperature. If these empty spaces migrate preferentially in the direction of a tensile stress and if the grain boundaries across which a tensile stress is maintained can more readily accommodate vacant sites, the latter would accumulate in boundaries which lie at right angles to the stress direction. When a sufficient number of vacant sites have accumulated in any boundary, conditions for the breaking of cohesive bonds will have occurred, i.e. an intercrystalline crack will have started which will open out under the continued stress. These are the conditions which lead to intercrystalline cracking by creep. It is suggested that the prevention of migration of vacant sites, or the reduction of their number, would lead to reduction in the incidence of intercrystalline cracking.—ALL. 6807

3.5.8, 3.8.3, 5.3.4, 3.5.3

Effect of Sonic and Ultrasonic Vibrations on Electrochemical Processes. (In German). ALBERT ROLL. *Metalloberflache*, Sec. B, **4;** B49-B53, B65-B70 (1952) April, May.

First part covers effect of ultrasonic waves on metal passivity. Research shows that ultrasonics may prevent as well as increase passivity of surface coatings. The qualitative effect of weak ultrasound is similar to mechanical stirring. Intense ultrasound changes or destroys passivation by cavitation and impairment of passivating coatings. The second part discusses effect of different factors on electrolytic separation of gases under influence of ultrasonics. The third part deals with electrodeposition of metals in the presence of ultrasonic waves, covering the literature and apparently some experiments by the author. Diagrams and graphs. 18 references.—BTR. 6337

3.5.8, 4.3.2, 6.2.3

Dissolution of Steel in Sulfuric Acid under the Influence of Ultrasound. A. P. KAPUSTIN AND M. A. FOMINA. *Doklady Akad. Nauk SSSR*, **83,** No. 6, 847-849 (1952).

Lack of data on the effect of ultrasound upon fusion (dissolution) processes. Author's study of influence of rapid mechanical vibrations on dissolution rates of various substances, particularly of steel. Results of preliminary experiments. Main experiments: Procedure. Exposure of steel plates immersed in 1 normal sulfuric acid to ultrasound and effect of exposure on rate of dissolution. Relationship between ultrasound intensity and amount of steel dissolved. Translation available H. Brutcher, Box 157, Altadena, California. 6342

3.5.8, 5.1.0

Grease Feedability Reduces Fretting Corrosion. E. W. HERBECK, JR. AND R. F. STROHECKER. *Aviation Age*, **18,** No. 3, 6-16 (1952) Sept.

A survey of past work on the effect of lubricants on fretting corrosion showed conflicting results regarding the relative merits of specific lubricants and additives. It is generally agreed, however, that feedability and maintenance of lubricant film between rubbing surfaces are prime factors in minimizing fretting.

On the basis of work performed at Beacon Laboratories with grease lubricants on a Fafnir dual-unit thrust bearing friction oxidation tester, in which the effects of soap base, consistency and additives on fretting corrosion were evaluated, the following conclusions were drawn: 1) Lithium soap will not by itself minimize or eliminate fretting corrosion. 2) Mineral additives such as zinc oxide or molybdenum disulfide will not reduce fretting corrosion when incorporated in a grease which in itself allows severe fretting. 3) Shear-susceptible greases will work down and minimize fretting corrosion regardless of soap type or initial consistency. 4) A grease with a worked penetration of 320 or more, even though shear-resistant, will minimize fretting corrosion. 5) The degree to which a grease will minimize fretting corrosion appears to be a function of its consistency (feedability) under the action of bearing shear.—PDA. 6688

3.5.8, 6.4.2, 2.4.2, 3.8.2

Stress Corrosion in Aircraft Alloys: Final Report. JOSEPH B. MCANDREW AND HOWARD T. FRANCIS. Armour Research Foundation, May 29, 1952, 23 pp.

An attempt has been made to verify the existing theory for the stress-corrosion cracking of aluminum-4% copper alloy. The approach used has employed a scanning device, called a "corroscope," which permits a two-dimensional picture to be observed on an oscilloscope, in which is shown the potential distribution in the electrolyte immediately adjacent to the corroding metal surface. Since this potential field is directly related to the current lines flowing from point to point on the specimen, the picture allows direct observation of the location of anodic and cathodic regions on the surface. The x and y directions represent distances on the specimen surface, while the z direction (intensity) reflects the presence of anodic or cathodic elements of the corroding system. Experiments with models verify the reasonably good resolving power and sensitivity of the method. Experiments in which the corroscope has been applied to a study of aluminum-4% copper have failed to demonstrate that appreciable currents flow between grain-boundary and grain-center zones of the metal. In view of this result, and in consideration of recent publications by others, a modification of the Dix theory is offered as follows: The grain body-grain boundary couple currents are presumed to serve as an "activating" mechanism for the onset of rapid localized attack at the crack site. This rapid corrosion is thought to occur as a result of the loss of film-repairing ability by the grain-boundary material, brought about in turn by the (relatively small) couple currents. Several experiments are outlined which should permit a test of this hypothesis.—NSA. 6694

3.5.8, 6.4.4, 3.5.3, 3.8.3

Metallic Corrosion (of Magnesium) Influenced by Ultrasonic Waves. SHIGETO YAMAGUCHI. *J. Applied Physics*, **23,** No. 9, 1057-1058 (1952).

Two magnesium specimens were subjected to attack by 3 percent sodium chloride solution for five hours at room temperature. In one case the solution was still; in the other it was agitated ultrasonically at 1 mc/s and an amplitude of 2.5 w/cm.^{2} The second specimen was barely attacked, unlike the first. It is thought that this passivity is due to prevention of the normal coagulation of

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magnesium oxide and magnesium hydroxide; these corrosion products form thixotropic aqueous suspensions, which are known to coagulate more slowly if ultrasonically agitated. The fine product particles act protectively. At double the amplitude corrosion-erosion of the corrosion products led to increased attack. —MA. 6338

3.5.8, 6.5, 3.7.2

Segregation and Stress Corrosion of Non-Ferrous Metals. (In French). J. F. G. HERENGUEL. *Metaux: Corrosion-Industries*, 27, No. 326, 379-385 (1952) Oct.

The mechanism of stress corrosion under both internal and external stress is discussed. Aluminum-magnesium alloys are more sensitive to stress corrosion than aluminum-copper alloys, although these also suffer intergranular corrosion when annealed at high temperatures. For best resistance to stress corrosion, the magnesium content of aluminum alloys should be limited to 5 percent. Even at ordinary temperatures, aluminum-zinc alloys are susceptible to severe intergranular corrosion, with or without mechanical stress, owing to the separation of zinc at the intergranular boundaries. Additions of copper, silver, chromium, zirconium, silicon, iron, vanadium, titanium and manganese decrease this effect, whereas zinc, magnesium and alkali and alkaline earth metals tend to accelerate the segregation.

Copper-base alloys, particularly copper-zinc alloys, suffer characteristic "season-cracking," especially in atmospheres of mercury and ammonia or in solutions of their salts. Additions of phosphorus, arsenic, manganese and especially silicon tend to improve the corrosion resistance of copper alloys. Aluminum bronzes under stress are also sensitive to attack by ammonia, particularly if their aluminum content surpasses 3 percent. Copper-nickel alloys seem less sensitive, except under prolonged stress in mercurous nitrate solution. Tin bronzes are also susceptible, particularly if the tin content rises above 4-5 percent, but not as susceptible as brasses.

Magnesium-base alloys, particularly magnesium-aluminum-zinc alloys, are susceptible to stress corrosion and frequently suffer transcrystalline fracture. Magnesium-manganese alloys seem to be immune to stress corrosion. Pure lead and some of its alloys are susceptible in acetate solutions.

Intercrystalline failure can be brought about by mechanical stress in the absence of a corrodent. Addition of 1 percent silicon decreases the susceptibility to stress failure in aluminum-4 percent copper alloys, but is of disputed value for aluminum-magnesium alloys. Aluminum-zinc alloys and their modifications suffer intergranular segregation which accompanies their structural hardening without corrosion at ordinary temperatures. Similar behavior is shown by heat-treated, copper-base alloys at room temperature and at 500 degrees C. The presence of lead makes them susceptible to intergranular failure even at abnormally low temperatures. Brasses too suffer intergranular rupture at 100-600 degrees C when stressed without corrosive influences, the rate of fracturing depending on temperature, degree of applied stress, and zinc content. Lead and lead alloys are also susceptible to this type of failure.—PDA. 6690

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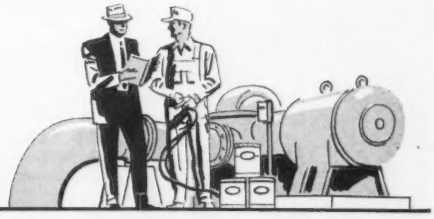

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3.5.9, 6.3.4, 7.1

Sintered (Cobalt-Chromium-Tungsten) Alloys for High-Temperature Service in Gas Turbines. R. W. A. BUSWELL, W. R. PITKIN AND I. JENKINS. Iron Steel Inst., Special Rep. No. 43 (1952), 258-268; discussion, 345-354; *GEC Journal*, **18**, No. 3, 139-156 (1951).

The development of a satisfactory sintered alloy of the Vitallium type (cobalt 64, chromium 30, tungsten 6%), having low porosity and properties comparable to those of the cast alloy, is described. The influence of particle size, compacting pressure, time and temperature of sintering and the sintering atmosphere on the α of the compact and its properties was investigated. The scaling-resistance of the best sintered products is high and the room-temperature mechanical properties are similar to those of the cast alloys, but at elevated temperatures the creep-resistance is low. The addition of small quantities ($\sim 0.1\%$) of ThO_2 results in an improvement in creep properties and the effects of carbon addition are being investigated. Sensitivity to aging treatments was noted, and the significance of the transformation from a fcc to a hcp structure is discussed. 11 references.—MA. 6707

3.6 Electrochemical Effects

3.6.6, 3.6.2, 5.8.2, 5.8.3

Protective Film Formation with Phosphate Glasses. G. B. HATCH. *Ind. and Eng. Chem.*, **44**, 1775-80 (1952) Aug.

The inhibition of the galvanic corrosion of steel coupled to cathodic metals by the glassy phosphates has been found to be chiefly the result of a marked polarization of the cathode. This polarization appears to result from the presence of a glassy phosphate film on the cathode. The film is laid down by an electrodeposition process. A similar process appears operative with uncoupled steel; film deposition apparently takes place on the local cathodic areas as the result of the local action currents. An additional factor enters into the inhibition in differential aeration cells with steel electrodes. The deposition of the glassy phosphate on the cathode causes its open-circuit potential to become less cathodic. Consequently, the potential difference between the two electrodes is lowered in the presence of the inhibitor. Both this decreased potential difference and the increased cathodic polarization are important factors in the reduction of the current flow in these differential aeration cells by the glassy phosphates.—NSA. 6740

3.6.8

A Polarographic Method for the Indirect Determination of Polarization Curves for Oxygen Reduction on Various Metals. III. Chromium, Molybdenum, Tantalum, Titanium, Tungsten and Zirconium. PAUL DELAHAY AND LEE J. STAGG. *J. Electrochem. Soc.*, **99**, 546-548 (1952) Dec.

Presents polarization curves for oxygen reduction on chromium, molybdenum, tantalum, titanium, tungsten and zirconium. Appreciable amounts of hydrogen peroxide are formed on all except zirconium and molybdenum.—BTR. 6809

3.6.8, 3.2.2, 3.8.2

Measured Potentials as Related to Corrosion and Polarization in Local Cells. THOMAS P. MAY AND F. L. LAQUE. *Corrosion*, **10**, No. 3, 91-94 (1954) March.

Following a brief review of the theory of reversible electrode potentials, irreversible electrode potentials of corroding metals are discussed with particular reference to corrosion rates. Experiments in sea water provide evidence that neither reversible nor irreversible potentials can be used to estimate corrosion rates. The Mears and Brown concept of local cell action explains this lack of co-ordination. Polarization properties similarly account for the observed galvanic corrosion when dissimilar metals and alloys are coupled. Anodic and cathodic currents from an external source were applied in separate experiments to steel in flowing sea water. Potentials measured at several current densities permitted the construction of anodic and cathodic polarization curves. These potentials and corresponding corrosion rates permitted the construction of approximate polarization curves for the local anodes and cathodes on steel in flowing sea water. 6747

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5. PREVENTIVE MEASURES

5.3 Metallic Coatings

5.3.2

Supplement No. 1 to Draft German Standard DIN 50 960. (In German). G. SCHIKORR. *Werkstoffe u. Korrosion*, 3, No. 11, 328-332 (1952) Nov.

In a short introduction the author refers to the differences in the lives of similar metallic coatings on steel exposed in different parts of the world. He says that most metals corrode about half as fast in industrial and seaside districts in America as they do in similar districts in Central and Western Europe. The difference is attributed to the lower relative humidity of the air in America. The rest of the article is a reprint of the supplement to the draft standard, which contains notes on the behavior of various plated coatings, including zinc and cadmium, when exposed indoors, and out-of-doors both inland and by the sea. Rates of corrosion are tabulated.—ZDA. 5924

5.3.2, 2.2.5, 8.1.2

Aluminium Coated Steel Plate. *Metal Ind.*, **82**, No. 5, 88 (1953) Jan. 30.

Discusses the protection afforded to a steel building by a sprayed aluminum coating. Test house was built in 1937. Outer surfaces of the steel plates were grit blasted and sprayed with aluminum. In 1946, 2 coats of an aluminium paint were applied; in 1952, the sprayed aluminum coating was still in good condition. 15 years is about the maximum life that can be expected from a sprayed aluminum coating.—INCO. 6133

5.3.2, 4.2.4

Corrosion Resistance of An Aluminum Coating. *Engineer*, **195**, No. 5062, 188 (1953) Jan. 30.

A steel building in Sheffield, England was finished in 1938 and at that time the exterior walls were sprayed with aluminum. A 3-ft. high dado was covered with two coats of black bituminous paint and a coat of lacquer. In 1952 the aluminum coating was found in good condition, although slight rust staining and small patches of rust were observed, including a band 3 ft. wide over a window where 10% rusting had occurred. It is estimated that the maximum life of such a coating on similar structures would be 15 years, where highly corrosive works atmospheres are present. —ALL. 6024

5.3.2., 4.2.5

Tests of the Protective Value of Metallic Coating Under Sheltered Conditions (Marine Atmospheres). S. G. CLARKE and W. N. BRADSHAW. *J. Appl. Chem.* (London) **3**, Pt. 4, 147-154 (1953) April.

Results of tests on the corrosion of various coatings on steel (electroplated zinc, cadmium, tin, lead, silver, lead-tin, tin-zinc and sprayed aluminum) and of silver coatings on aluminum are presented. Tests were carried out with reference to the behavior of parts that are to be used or stored inside unsealed boxes, lockers or cabinets in a marine environment. Order of merit of coatings in preventing rusting was broadly 1. cadmium, zinc, 2. tin-zinc, 3. lead, tin and lead-tin. Effect of sulfurous pollu-

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Highly versatile, Dressertape is widely used for coating field-welded joints on all diameters of mill-wrapped pipe . . . for complete coating of pipe sections in yard or ditch . . . for repairing holidays and gaps in other types of coating. Readily conforming to the contours of small diameter fittings, narrow-width Dressertape is ideal for service line use.

GIVES LASTING PROTECTION

High dielectric Dressertape provides excellent electrical insulation . . . also permanently protects all underground piping against corrosion by soil chemicals, salt water, acids, alkalies and oil.

For complete details, send for Dresser "Corrosion Control" catalog.

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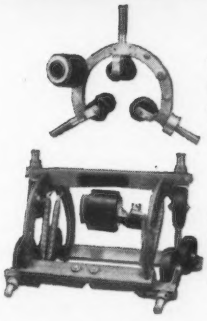

The Tapester Special, available through Dresser, assures speedy, uniform coverage on small diameter pipe.

Larger model Tapesters, also available through Dresser, spin Dressertape protection on piping 2" in diameter and larger.

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Dresser Manufacturing Division, 89 Fisher Ave., Bradford, Pa. (One of the Dresser Industries). Warehouses: 1121 Rothwell St., Houston; 101 S. Airport Blvd., S. San Francisco. Sales offices also in: New York, Philadelphia, Chicago and Toronto.

tion from industrial and domestic combustion products is far-reaching, and produces a strong sulfate component in a marine test-location remote from large towns. Tables, graphs and 7 references.—INCO. 6245

5.8 Inhibitors and Passivators

5.8.1

Inhibition of Corrosion. U. R. EVANS. Paper before Soc. Chem. Ind., Corrosion Group & Manchester Sect., Symp. on Corrosion Inhibitors, Mar. 27, 1953. *Chemistry & Industry*, No. 22, 530-533 (1953) May 30.

Principles of inhibitive action, dealing first with the action of oxygen during dry oxidation and wet corrosion and explaining how inhibitive additions could prevent corrosion which would otherwise occur owing to breakdowns at sensitive points in oxide films are summarized. Oxidizing and other anodic inhibitors, which were liable to cause intensified attack if added in insufficient concentration, were discussed as well as cathodic inhibitors and organic inhibitors. 25 references.—INCO. 6327

5.8.2, 6.2.2, 4.3.2, 5.4.5

The Anti-Corrosive Properties of Aluminohemicellulose. A. P. ANTYKOV. *J. Applied Chem.* (USSR) (Zhur. Priklad. Chim.), **25**, 41-47 (1952) Jan.

Ferrous articles exposed to dilute sulfuric acid (10.3-26.3%), can be protected against rusting by dissolving in the acid 0.2-0.95% aluminohemicellulose. This inhibitor is more effective than any of a number of inhibitors tested including sulfates. Successful protection against dilute sulfuric acid and also against atmospheric oxygen is obtained by coating the ferrous metal with a Bakelite or other acid-resisting varnish containing 0.2-5% of aluminohemicellulose. For best results the iron surface should be as free of rust as possible. Aluminohemicellulose does not protect against corrosion by hydrochloric or nitric acid; it has some inhibiting effect in 85 percent phosphoric acid.

Aluminohemicellulose is produced by adding solium aluminate to "black liquor," a useless by-product of the viscose industry. The liquor contains 1.8-4% hemicellulose.—PDA. 6758

5.8.2, 6.4.2

Inhibited Interleaving Tissue Prevents Water Staining of Aluminum—A Technical Note. *Corrosion* (Technical Section) **9**, No. 8, 295 (1953) Aug.

Aluminum sheets packed unoiled may be protected from water staining by being interleaved with tissue paper to which has been added 1.5 to 3 % sodium chromate by dry weight. Alloys tested were 3S and 23S-F. This development of the Kaiser Aluminum and Chemical Corporation Division of Metallurgical Research is protected by patents.—ALL. 6302

5.8.2, 8.4.3

Organic Inhibitors Improve Ammonia Control, Reduce Sulfide in Refinery Waste Waters. J. J. HUR. *Corrosion* (News Sec.), **10**, No. 2, 1 (1954) Feb.

High molecular weight, semi-polar organic compounds used in crude still overhead systems to supplement ammonia used for corrosion control has resulted in substantial reductions in corrosion. Some of the inhibitors control corrosion without ammonia and all reduce sulfide content of waste waters, causing the sulfide to remain in the gas phase from which it can be reacted to sulfuric acid. 6813

5.8.2, 8.4.3, 2.3.1

Laboratory Methods for Evaluation of Inhibitors for Use in Oil and Gas Wells. E. C. GRECO AND J. C. SPALDING, JR. *Corrosion*, **10**, No. 3, 103-109 (1954) March.

The short range purpose of this article is to present to all interested in the problem the possible methods that may be used in the laboratory for such evaluation work and at the same time to solicit from all those receiving this report information that may lead TP-1 to the adoption of or, at least, recommendation of standardized laboratory procedure. The latter action, of course, is the long range purpose of this work.

Data gathered from companies canvassed indicate the majority working in this field still rely upon corroding systems as set up in the laboratory (whether reflecting field conditions or entirely synthetic) to produce weight loss upon coupons made from material expected to be used in the field. In addition, there are a few companies working on such varied methods of laboratory evaluation as the determination of: 1. film resistivity; 2. hydrogen evolution; 3. drop size ratio, etc.

One discusser deals with static tests and sessile drop tests. He points to several theoretical and practical objections to the drop test, asserting that the drop test is unreliable because wettability criteria cannot be translated always into inhibitor efficiencies. The question of interfacial tensions between metals and fluids is considered with the conclusion that the distinction between adsorptive and oil wetting inhibitors is not clear. The discusser does not believe that contact angle measurements can be used theoretically to predict the extent of oil or water wetting of a surface or that it can be assumed that oil-wet surfaces will not corrode.

A second discusser outlines the methods used by one company in determining the efficiency and economies of inhibitors. Tests with wetting agents are described in which the rate of adsorption of water dispersable inhibitors may be checked.

He concludes selection of inhibitors by the drop-size ratio or oil-wetting tests is reliable for oil and gas wells but not for gas condensate wells. Speed of the drop size ratio method and the possibility of quantitative recommendations are assets also. This factor is important as indicated by a study which showed a range of inhibitor costs per barrel from $0.009 to $0.224. 6826

5.8.4

The Inhibiting Action of Aldehydes. (In Russian). V. S. KEMKHADZE AND S. A. BALEZIN. *J. Gen. Chem.* (USSR) (Zhur. Obshchei Khim), **22**, 1848-1855 (1952).

The prevalent assumption that the corrosion-inhibiting effect of aldehydes increases with increasing molecular weight is shown to be erroneous. There is evidence that aldehydes act on steel in aqueous acid solution in two opposing ways —they either inhibit or accelerate the process of dissolution. At a given aldehyde concentration one or the other tendency is predominant. The inhibiting action of a given aldehyde increases with rising concentration but only up to a limiting value. The speed of reduction of the aldehydes and the stimulation of corrosion increase with increased concentration but generally diminish with increasing molecular weight.

The branched-chain *iso*-butyraldehyde is a better inhibitor than the straight-chain *n*-butyraldehyde. Aldehyde emulsions are also shown to possess inhibiting properties —PDA. 6777

5.9 Surface Treatment

5.9.1

Metal Cleaners. MILTON A. LESSER. *Soap, Sanit, Chemicals*, **28**, Nos. 10 & 11; 42-44+, 46-49+ (1952).

The subject is reviewed under the headings: cleaning test methods, radioactive-tracer use, alkaline cleaners, syndets for soap, soak-type cleaners, electrocleaners, chlorinated hydrocarbons, diphase cleaner, acids and special cleaners. 97 references. —MA. 6660

5.9.2

Evaluation of the True Efficiency of Pickling Inhibitors. (In Italian). LEO CAVALLARO AND LILIANA FELLONI. *Metallurgia Italiana*, **44**, 366-370 (1952) Aug.-Sept.

Various organic compounds were investigated with respect to their inhibitive effect on pickling of carbon steels. The method used is described; results are tabulated and interpreted.—BTR. 6734

5.9.2, 2.4.3, 2.3.9

Radioactive Tracers Track Metal Cleaner Effectiveness. J. W. HENSLEY. *Iron Age*, **170**, No. 20, 151-154 (1952) November 13.

In determining the effectiveness of metal cleaners, radio-active tracers provide a technique capable of extreme sensitivity and quantitative measurements of trace quantities without the limitations and complications usually inherent in highly sensitive quantitative methods. Cleaner compounds, normally alkalies and surfactants, are tagged by synthesized radioactive atoms and used to determine filming characteristics and adsorption on metal surfaces. Metals are tagged (by bombarding in an atomic pile) and used to study corrosion, attack by cleaners and the action of inhibitors in cleaners. Wyandotte Chemical Corporation tagged a fatty acid type soil with radioactive tracers and by a standardized procedure, the tagged soil was applied to prepared metal disks (steel and brass) 1.5 inches in diameter. Radioactivity was measured with a Geiger counter before and after cleaning. Indications are that this method could be adapted for shop use when data on shop variables are more complete.—ALL. 6718

5.9.3

Cleaning Work with the Aid of Ultrasonic Vibrations. CHARLES R. FAY. *Machinery* (London), **80**, No. 2061, 853-855 (1952); *Machinery* (NY), 58, No. 7, 158-161 (1952) March.

Fay describes a method of cleaning small precision metal parts by immersion in an ultrasonically activated solution. A power oscillator supplies voltage at 750 kc/s to a quartz crystal transducer which produces ultrasonic vibrations within a solution of C_2HCl_3 via a diaphragm. A slightly saline solution couples the crystals to the diaphragm.—MA. 6778

How Exon 402-A wipes out corrosion

Exact tolerances previously destroyed by corrosion

...are now kept micrometrically exact with

Boltaron 6200

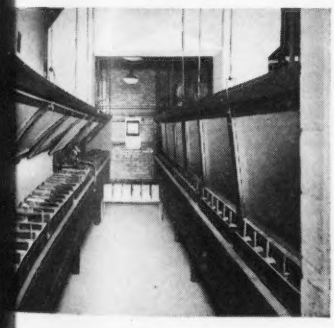
A 2-headed problem faced Norris-Thermador Co. of Los Angeles. They use large rings like stencils to plate copper onto kitchenware. Painfully exact tolerances are mandatory. But the corrosive solutions used ate away the tolerance, ruined rings, skyrocketed costs.

Engineers ransacked industry's resources for one material that could hold tolerance in so corrosive a solution. They found it in Boltaron 6200.

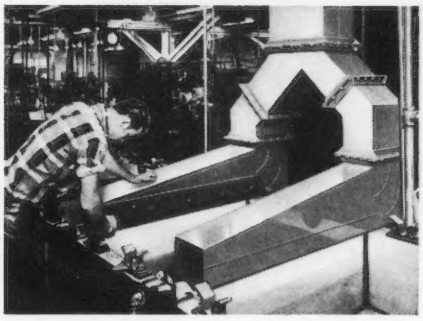
After a year, Boltaron 6200 rings show no sign of corrosion. Replacement costs? Wiped out!

Installation by Horace Blackman Co.

Photographs courtesy H. N. Hartwell & Son, Inc., Boston 16, Mass.

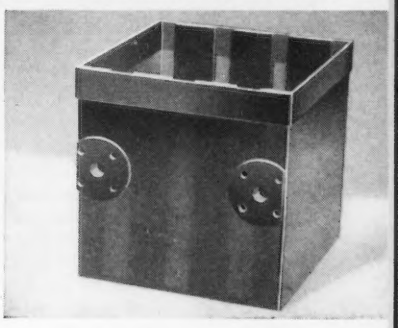


★For 18 months, sulfuric acid fumes have failed to corrode a Boltaron fume removal system at Electric Storage Battery Company, Fairfield, Conn.



★ Maintenance costs were wiped out at Cannon Electric Co., Los Angeles. A metal-corroding solution of 33% nitric, 33% sulfuric acid and 33% fluoride salts has left Boltaron ducts and tanks unmarked for a year.

Installation by Horace Blackman Co.



★ Eastman Kodak Co., Rochester, reports that Boltaron 6200 remained completely uncorroded by ferricyanide after 3 years, when no other material lasted 3 months.

Installation by Industrial Plastic Fabricators, Inc.

New rigid, extremely versatile, light weight materials are making corrosion a memory in industry all over America. These unplasticized polyvinyl chlorides are typified by Boltaron 6200.

Firestone's Exon 402-A resin meets Boltaron's exacting specifications —best assurance of uniform results under the most corrosive conditions.

These materials can be welded, sawed, sheared, stamped, milled, molded, planed, drilled, embossed, rolled and cemented—on conventional woodworking or metalworking equipment.

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NOTE: Firestone supplies the resin only, does not manufacture the end product.

CLEANING, COATING, WRAPPING & RECONDITIONING

★

HOT DOPE

Straight from the Kettle on PIPE PROTECTION

★

By Boyd Mayes

• **We had a character back up home in East Texas who had a fancy for raisin' peas on his little strip of sandy land. One day, while we were walkin' a gun and chasin' a squirrel, we ran slap-dab into the old codger workin' on his fence and cussin' something terrible. "Looks like," we said to him, "here's where some of your cows got out." With much disgust, he answered, "No, here's where some of *his* cows got in. I fence *agin him!*" Somehow, we could never forget the old man's philosophy, his attitude and the job he was working so hard at. It reminds us of our own job . . . fencing *"agin"* corrosion, the number one problem of pipelining. While the best engineering research known to modern science has yet to lick the corrosion problem, they're making some real strides toward it. Meantime, we keep fencing *agin* it by *putting permanence in pipe* through 26 years of know-how in cleaning, priming, coating and wrapping line pipe before it goes into the ground. We've prepared enough pipe for trouble-free service to reach . . . end to end . . . nearly three times around the world. And that includes sizes ranging from ½" to 72". Our skilled craftsmen and up-to-the-minute equipment are ready for your next job of fencing *agin* corrosion.**

MAYES BROS.

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5.9.4

Importance of Water Control in Phosphatising. E. FANEUF. *Finish,* **9,** No. 10, 29-31 (1952).

Three materials that cause rapid failure of enamels on phosphatized steel when the finished steel is subjected to humid conditions are: 1) by-product salts of the phosphatizing operation; 2) hard water salts; 3) salts from the chromic/phosphoric acid rinse. Demineralized water for the final rinse reduces these effects to a minimum.—RPI. 6775

5.9.4, 1.3

Phosphate Coating Progress, 1945-1952. Parts I & II. A. R. KING. *Paint Manuf.,* **22,** Nos. 9 & 12, 325-329; 463-465, 472 (1952).

A review of developments during the last seven years. There have been many interesting developments, although the popular processes of the previous decade (1935-1945), are still very widely used. The main developments have been in mechanical methods of application such as the tipping basket and other dipping and cyclic flow techniques, improved test methods and specifications, rapid iron-phosphate treatments, derusting by phosphoric acid metal conditioners incorporating organic grease solvents and surface activators and cold phosphating, especially for rusty surfaces.—RPI. 6803

5.9.4, 5.9.2, 5.4.5

Trouble with Phosphate/Paint Coating Systems. *Electroplating,* **5,** No. 12, 413-414 (1952).

Incomplete phosphating of girders with the formation of a thick black sludge on the surface of the metal was shown to be caused by decomposition of the wetting agent and inhibitor in the sulfuric acid pickle. An account is given of the amended treatment to overcome the difficulty. Another failure of primed girders was finally attributed to incomplete mixing of the zinc chrome primer used.—RPI. 6657

6. MATERIALS OF CONSTRUCTION

6.2 Ferrous Metals and Alloys

6.2.1, 5.9.1

The Cleaning of Iron and Steel Before Applying An Organic Coating. (In Dutch). A. GROENENDIJK. *Metalen,* **8,** No. 8, 2-8 (1953) Apr. 30.

Various methods and agents, especially the effect of phosphoric acid. Practical advantages of well-composed rinsing baths and applications. Photographs.—MR. 6336

6.2.2, 3.2.3, 2.3.9

Study of Process of Oxidation (Rusting) of Iron by the Isotope Method. E. I. DONTSOVA. *Doklady Akad. Nauk SSSR,* **85,** No. 1, 165-167 (1952).

Report on experiments on the rusting of iron at room temperature in a limited, strictly predetermined quantity of water (to obtain quantitative data) by the use of the isotope (O^{18}) method. Experimental procedure. Results of experiments conducted on pure reduced iron and on technical irons with standard water whose isotope composition was zero, in the presence of oxygen from the atmospheric phase, with an excess content of +93 γ of the heavy oxygen isotope. Distribution of oxygen isotopes between water and oxidation products; results of computations and their verification by experiment. Rate of oxygen isotope exchange with primary as against final oxidation products. Oxygen ultimately remaining in natural sedimentary iron oxides formed in a large excess of water and in the presence of atmospheric oxygen. Translation obtainable from: Henry Brutcher, Technical Translations, P. O. Box 157, Altadena, California. 6799

6.2.2, 4.3.2

Corrosion. M. G. FONTANA. *Ind. and Eng. Chem.,* **45,** No. 3, 91A-92A, 94A (1953) Mar.

Chart showing the corrosion of Ni-Resist Type I (copper bearing Ni-Resist) by sulfuric acid as a function of temperature and concentration for air-free acids is discussed. The effects of aeration and a combination of aeration and agitation on corrosion rate and copper and chromium content on corrosion resistance are considered. In general, ordinary cast iron and steel show essentially the same corrosion resistance under most sulfuric acid conditions. Ni-Resist Type 3 is sometimes used in fuming acids because it resists cracking. E. A. Tice (Inco) supplied some of the corrosion data. Composition ranges of Ni-Resist irons, including nickel content are tabulated.—INCO. 6314

6.2.2, 4.3.2

Corrosion. M. G. FONTANA. *Ind. and Eng. Chem.,* **45,** No. 5, 91A-92A, 94A (1953) May.

Corrosion of high silicon iron, Duriron, by nitric acid as a function of temperature is summarized in chart form. Corrosion resistance of Duriron increases as the concentration of acid is increased. Table.—INCO. 6312

6.2.3, 6.2.4, 3.7.3

On the Decomposition of Retained Austenite in Steel When Being Shot Peened. N. A. KARASEV. *Vestnik Mashinostroeniya,* **32,** No. 1, 44-46 (1952).

Steel compositions studied for transformation of retained austenite as a result of shot peening: 1) 0.15 % carbon, 0.90 % chromium structural steel; 2) 0.20 % carbon, 1 % manganese, 1.10 % chromium steel; 3) 0.17 % carbon, 3½ % nickel, 1½ % chromium steel; 4) VCI type high-speed steel; 5) 0.90 % carbon, 4.4 % chromium, 12.3 % tungsten, 2.5 % vanadium high-speed steel. Results of micrographic analysis of steels before and after shot peening. Effect of shot peening time upon transformation of retained austenite and surface hardness. Maximum peening time required for decomposition of retained austenite. Possibility of improving the current heat treating practices for carburizing and high-speed steels e.g. by substituting shot-peening for the double draw for twist drills. Translation available from: Henry Brutcher, Technical Translations, P. O. Box 157, Altadena, California. 6797

6.2.5

Nature of the Phenomenon of Passivity of the 18/8 Chromium-Nickel Steels. C. CARIUS. Paper before Deutsch. Ges. f. Metallkunde, Oct., 1952. *Metall,* **6,** 768 (1952) Dec.

Describes treatment consisting of activation in hydrochloric acid, followed by electrochemical or chemical (hydrogen peroxide) passivation at high potential. —INCO. 6680

It's just this easy...

to protect with "Scotchrap"!

Two men wrap 100 ft. of 8-in. gas line in 30 minutes

Fast! Easy! Clean! That's the "Scotchrap" story. No clumsy applicating equipment needed. No danger from burns. And remember: two *untrained* men wrapped 100 ft. of gas line in 30 minutes—1,000 ft. in only 5 hours.

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6.2.5, 3.2.2, 3.7.1, 3.5.8

Transgranular Stress Corrosion in Chromium-Nickel Stainless Steels. C. EDELEANU. *J. Iron Steel Inst.* (London), **173,** 140-146 (1953) February.

Metallographic evidence shows that a martensitic phase is produced on straining austenitic steels and that this phase is corroded preferentially. Steels in which the austenite does not readily transform on straining are less susceptible to cracking.

Experimental steels confirm that susceptibility to cracking can be reduced or largely avoided either by increasing the nickel content of the normal steels, thereby increasing the stability of the austenite, or by reducing the alloy content, thereby producing steels which contain large quantities of quasi-martensite and in which the corrosion is less localized and less likely to cause cracking. Increasing the chromium content also leads to some improvement, presumably because the austenite in the resulting two-phase alloys is relatively stable at low temperatures.

All standard grades of austenitic steels can suffer transgranular stress corrosion in concentrated and dilute magnesium chloride and other chloride solutions and there is evidence that oxidizing agents can accelerate failures. Impure steam can also cause stress corrosion.

Annealing treatments above 850 degree C followed by slow cooling should remove internal stresses, but welds between austenitic and ferritic steels cannot be effectively annealed.—PDA. 6303

6.2.5, 3.2.3, 3.8.3

Passivity of Stainless Steels in an Acid Medium. (In French). J. M. DEFRANOUX. *Rev. met.,* **49,** 664-672 (1952) Sept.

The progressive establishment of passivity of stainless steels in strong acid media is clearly observable on initially active surfaces in a medium of relatively low oxidizing power. Initially passive surfaces seem to undergo an adaptive phenomenon which comprises a transformation from "initial passivity" to "acquired passivity" in the medium. Passivation occurs in two successive phases —establishment of an equilibrium potential and subsequent reinforcement of the acquired passivity.

Passivity appears to be permanent only if the medium exceeds a certain oxidizing power whose lower limit is a function of environmental conditions such as acidity and temperature. If this condition is not realized, all passivation treatments should be used cautiously because any accidental reactivation will be permanent. On the other hand, any medium in which an active steel surface becomes spontaneously passive assures perfect safety with respect to permanence.

Stainless steels immersed in a medium of extreme oxidant power suffer a special type of corrosion characterized by a high electropotential. Oxidation is associated with the so-called "transpassive" state. The oxide film accompanying this surface state appears to furnish only partial protection, although it is postulated to be of the same nature as that accompanying the passive state in an acid medium. There is thus a continuous transition between passivation and transpassivation.

In a strongly acid medium, both surface states (passivity and transpassivity) are apparently characterized by the oxidation of metal to an oxide, followed by the redissolution of this oxide, whereas the state of activity is characterized by the direct dissolution of the metal as ions and the absorption of simultaneously liberated electrons by hydrogen ions to form molecular hydrogen. The relative affinity of these two possible reactions—direct dissolution or oxidation with subsequent dissolution—will decide whether stainless steel acquires permanent activity or permanent passivity in a given medium.

The prime cause of passivity is not the formation of a passivating film but the realization of certain conditions which are determined by the thermodynamic characteristics of the medium, as shown by potential/pH diagrams, and which are responsible for the formation and stability of the passivity film.—PDA. 6687

6.3 Non-ferrous Metals and Alloys—Heavy

6.3.6, 3.2.3

Structure of Copper Scale and Mechanism of the Oxidation of Copper. (In Russian). N. P. DIEV AND M. I. KOCHNEV. *Doklady Akad. Nauk SSSR,* 85, No. 3, 563-566 (1952) July 21.

Oxidation rate of cathode copper is much greater above 1025 degrees C, the scale then consisting of a solid solution of copper in cuprous oxide. Scales formed at 600-1025 degrees C consist of thin outer layer of cupric oxide and thicker layer of cuprous oxide, growth taking place by diffusion of copper and oxygen to the boundary between the two.—BNF. 6760

6.3.6, 3.2.3, 5.4.2

Dry Oxidation of Copper and Its Alloys. V.—Selective Oxidation of a Copper-Beryllium Alloy. L. HUBRECHT. *Bull. soc. chim. Belges,* **61,** No. 6/7, 205-214 (1952).

It is shown that highly protective films of beryllium oxide can be formed on such alloys by heating to a temperature above 600 degrees C on condition that the partial pressure of oxygen in the atmosphere is maintained below 0.02 mm mercury. The alloys, after this treatment, are unaltered in normal atmospheres up to 400-500 degrees C. Untreated samples are, however, rapidly oxidized at such temperatures and the films formed contain a little beryllium oxide and large quantities of copper oxides.—MA. 6802

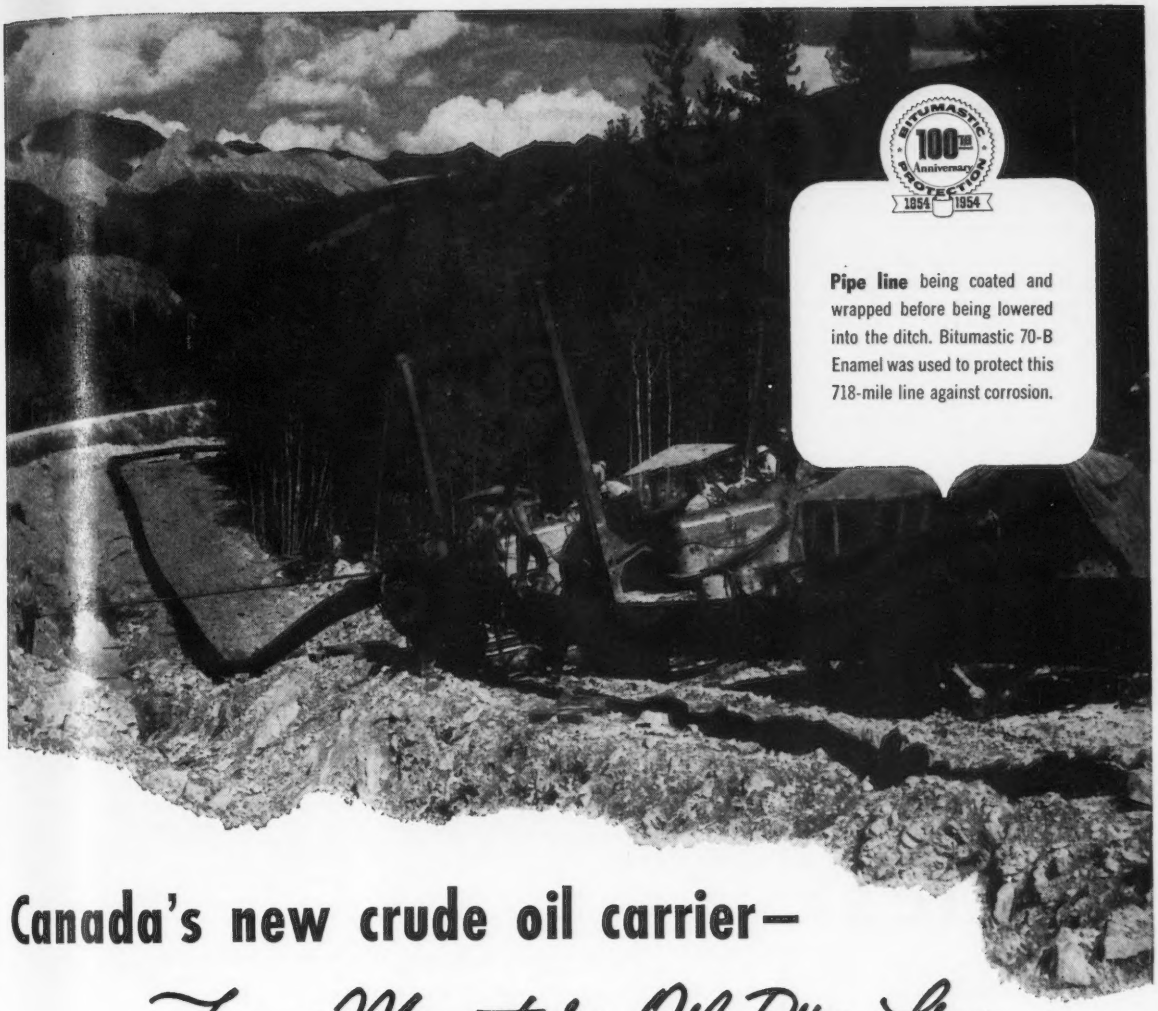
6.3.6, 3.7.4, 3.7.2, 3.2.2

The Embrittlement of Copper-Antimony Alloys at Low Temperatures. D. MCLEAN. *J. Inst. Metals,* **81,** 121-123 (1952) Nov.

Charpy tests on bars with an Izod V-notch have been carried out from +100 to —253 degree C on slowly cooled copper alloys containing up to 1.3 percent antimony. In these alloys the antimony is thought to have been entirely in solid solution. Alloys containing between 0.14 and 0.56 percent antimony became brittle at low temperatures, the embrittlement being reversible and generally similar to that of ferritic steels at low temperature.

Since no grain-boundary precipitate was seen in the alloys of highest antimony content, brittleness is believed to be due to grain-boundary segregation of antimony without precipitation.

The suggestion is often made that, as the test temperature decreases, the



Pipe line being coated and wrapped before being lowered into the ditch. Bitumastic 70-B Enamel was used to protect this 718-mile line against corrosion.

Canada's new crude oil carrier—

Trans Mountain Oil Pipe Line

—protected by Bitumastic 70-B Enamel

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transition from tough to brittle behavior is a function of lattice type, probably because such a transition is invariably observed with ferritic (body-centered cubic) steel, but not with austenitic (face-centered cubic) steel or with the common nonferrous face-centered cubic metals. The transition has, therefore, been sometimes thought to be a property of the body-centered cubic lattice; however, not all body-centered cubic lattice metals show this transition.

A feature common to all metals having tough-to-brittle transitions, however, is the actual or probable presence of impurity atoms that severely distort the parent lattice and can reasonably be supposed to cause the transition. Foreign impurity atoms will segregate to distorted lattice regions, thereby replacing the randomly distributed strained spots by fewer but larger stressed areas, such as grain-boundary interfaces and leading to macroscopic brittle fracture behavior. Moreover, with decreasing temperature, distorting atoms will probably increase the yield stress until it exceeds the fracture stress causing failure. The necessary conditions for brittle behavior are more easily attained in notched specimens, in which the triaxial stress at the root of the notch raises the effective yield stress. The body-centered cubic and hexagonal metals often fracture along cleavage planes instead of along grain boundaries. Interstitial atoms present in body-centered cubic lattices may tend to aggregate on cleavage planes, because the total strain energy may thereby be reduced.

Similar aggregation is likely in hexagonal metals, but unlikely in face-centered cubic metals. These aggregates will inevitably embrittle along the cleavage planes and so may cause cleavage fracture; however, such fracture would be improbable in face-centered cubic metals.—PDA. 6686

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6.3.6, 4.7

Stress-Cracking of Copper by Mercury. J. N. GREENWOOD. *Bull. Inst. Metals,* **1,** No. 19, 177-178 (1953).

A letter. The effect of mercury applied to the surface of annealed specimens of OFHC and tough-pitch copper strained at 0.2, 40 and 1000 %/hour at room temperature has been investigated. The results show that the maximum stress is not significantly affected, but that the elongation is appreciably lowered, particularly at low strain rates. Microscopic examination showed that the fractures were intercrystalline. Copper has previously been thought to be immune from stress-cracking by mercury and this view must be altered.—MA. 6330

6.3.8, 8.4.3

The Corrosion of Lead in the Petroleum Industry: Parts 1, 2 & 3. M. KARSULIN AND T. MARKOVIC. *Nafta* (Yugoslavia); **3;** 311-15, 353-9, 393-8 (1952) Oct., Nov., Dec.

The behavior of lead in solutions of sodium hydroxide, hydrochloric acid, sodium chloride and sulfuric acid was studied (Part I). In Part 2, the corrosion phenomena were studied from the viewpoint of mechanical inhomogeneity of lead surfaces, by determining the current strength of an element consisting of two lead plates of the same chemical composition but different surface smoothness in sulfuric acid. Part 3 discusses a similar study using sodium hydroxide as electrolyte. The influence of the anode surface on the depolarization current in rough and smooth platinum-lead elements was also discussed and the action of sulfur-containing agents in the electrolytes was studied. (30 references). 6667

6.3.8, 3.2.3, 3.8.4

Scaling of Lead in Air. ELMER WEBER AND W. M. BALDWIN, JR. *J. Metals,* **4,** No. 8, 854-859 (1952).

A study has been made of the oxidation of lead (approximately 99.94%) at temperatures of 250°-800°C., i.e. covering both the solid and the quiescent liquid metal, X-ray analysis being used to determine the nature of the oxide films formed. Solid lead, between 254° and 321°C., obeys a single parabolic law of wt. increase/time, the scale formed being β (red, tetragonal) lead oxide. Liquid lead scales according to three successive parabolic relations, the time of transition becoming shorter with increasing temperature. The first parabola has a low constant; the scale (sooty black in color) is thin and yields diffraction lines of Pb_3O_4, Pb, and α (yellow, orthorhombic) PbO. The second parabola has a much higher constant; the scale contains Pb_3O_4, and β— or $(\alpha+\beta)$—PbO, according as to whether the temperature is less than or greater than 486°C. (the equilibrium temperature of β— and α—PbO), respectively. The third parabola has a constant only slightly lower than that of the second; the scale consists of β —PbO if formed below 486°C. or $(\alpha+\beta)$—PbO if formed above. The results are discussed in relation to those of Gruhl (*Z. Metallkunde,* **40,** 225 (1949); See Card No. 2659, classified 6.3.8, 3.7.2, 3.4.6), but no mention is made of the more recent work of Hofmann and Mahlich (*Werkstoffe u. Korrosion,* **2,** 55 (1951); See Card No. 2330, classified 6.3.8). 18 references.—MA. 5862

6.3.8, 3.7.4, 3.2.3, 2.3.5, 7.7

The Relation of the Anodic Corrosion of Lead and Lead-Antimony Alloys to Microstructure. J. B. BURBANK AND A. C. SIMON. U. S. Naval Research Laboratory. *J. Electrochem. Soc.,* **100,** No. 1, 11-14 (1953) Jan.

A technique is described for determining the relation of the microstructure of lead and its alloys to the anodic corrosion occurring in sulfuric acid. The method uses miniature storage cells made of methacrylate plaster with small positive-grid areas in which the conditons prevailing in a battery could be simulated. The positive plate is a disk of the test alloy presenting one side to cell action and backed up with a brass plug for electrical contact. A negative plate is hung in the cell neck; gaskets of polyethylene seal all joints. This method has been used to show how the corrosion of lead and of its hypoeutectic antimony alloys is related to their microstructures. Pure lead and alloys containing up to 0.5% antimony corrode intergranularly. Alloys above this concentration corrode by a combination of intergranular and interdendritic penetration of the antimony-rich network. In the range 0.5-6% the attack is preferentially intergranular. At higher antimony concentrations the corrosion is more evenly distributed between intergranular and interdendritic attack. The surface of castings containing 6% or more antimony are richer in antimony than the bulk of the casting. The described technique is a satisfactory short-term, laboratory-scale test for demonstrating the structural relation of the corrosion processes occurring in lead-acid storage batteries in actual use.—PDA. 6297

6.3.9, 3.2.3, 2.3.7, 5.4.2

On the Protection of Thin Deposits of Molybdenum by a Layer of SiO Obtained by Vacuum Evaporation. CHARLES FELDMAN. *Compt. Rend.,* **235,** No. 14, 706-707 (1952).

Electrical-conductivity measurements were made to determine to what extent a dielectric film (in this case silicon oxide) afforded protection to a metal (molybdenum) against the action of the atmosphere [cf. *ibid.,* **234,** 1858 (1952)]. A deposit $>1\mu$ thick afforded reasonable protection. Protected areas of the metal were exposed to a vacuum, to air at room temperature and to air at the temperature of liquid nitrogen. In vacuo aging is small—smaller than without a protecting film—probably owing to a modification in the structure of the film. At liquid nitrogen temperature there is at first a somewhat rapid variation of the electric resistance, then a slow diminution. But when the room temperature is reached, the resistance becomes exactly what it was before the specimen was cooled. Hence it appears that at low temperatures there is no oxidation of the film. An advantage of

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this method of study is that the rate of oxidation can be controlled by altering the thickness of the protecting film.—MA. 6739

6.3.10, 4.6.11, 3.2.2

Performance of Materials Tested in High Temperature Sea Water: "K" Monel Metal Chromium Plated. C. J. LANCASTER. U. S. Naval Engineering Experiment Station, Annapolis, Report No. 4A(15) 966870, January, 1952, 7 1.

Two K Monel sheet samples (66% nickel, 30% copper, 3% aluminum) coated with 0.0005-inch industrial chrome plate were exposed in a pressure vessel to static natural sea water at 500 degree F for 14 days. When removed, the samples showed discoloration ranging from straw color to dark blue. The discoloration was film-like and partially removable with an eraser, leaving slightly pitted surfaces. The discolored areas, as well as several dark spots on one side of each sample, which showed an etched appearance, were inactive when treated with a 60% solution of nitric acid, but the small bare areas at the end of the samples, which had been in contact with washers were quite active.

It is suggested that the minute metal particles, apparently copper, which appeared on the surfaces of the samples, partly randomly dispersed and partly in a crazed pattern, came from dissolution of the K Monel basis metal by a process akin to dezincification in brasses. The products of dissolution made their way through pinholes and minute fissures in the plating, the copper being readily redeposited on the plated surface from the static solution. These particles were easily removed by brushing and accounted for only 6 percent of the weight loss recorded for the samples.

The average corrosion rate of the two samples was 4.39 mg per sq. cm. per month, indicating that K Monel should be considered carefully for applications involving exposure to sea water at 500 degree F.—PDA. 6689

6.3.11, 5.3.4, 1.6

Modern Electroplating. Book. 1953, 563 pp. ALLEN G. GRAY, *Editor*. Sponsored by The Electrochemical Society, Inc. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y.

An exposition of modern electroplating theory and practice by 39 authorities. Contents range from general principles through methods of control and include separate sections on each of the commonly electroplated metals. An appendix of 15 pages gives tables of useful data for electroplaters.

The sole indexed item on corrosion covers a corrosion test for gold.

Each section includes numerous references to related technical material. 6323

6.3.13, 3.2.3, 3.8.4, 3.5.7

High Pressure Oxidation of Metals. II. Tantalum. WILLIAM MCKEWAN AND W. MARTIN FASSELL, JR. Utah University (NP-4243, Technical Report No. 2), Sept. 25, 1952, 17 pp.

Tantalum samples were oxidized in pure oxygen at temperatures of 500 to 600 degree C. The pressure was varied from 14.7 to 500 psi. The linear law was observed in every case. An Arrhenius plot was made of the data at 14.7 psi and two kcal/mole from 500 to 540 degree C and 46.1 kcal/mole from 540 to 600 degree C. The oxidation rate was found to vary directly with the pressure according to the equation $k = (0.297P + 10.0)$ mg cm²/hr, where P is in atmospheres. A mechanism was proposed involving a constant thickness film on the surface of the metal. This mechanism appears to explain the experimental data and the pressure effect.—NSA. 6798

6.3.14, 3.2.3

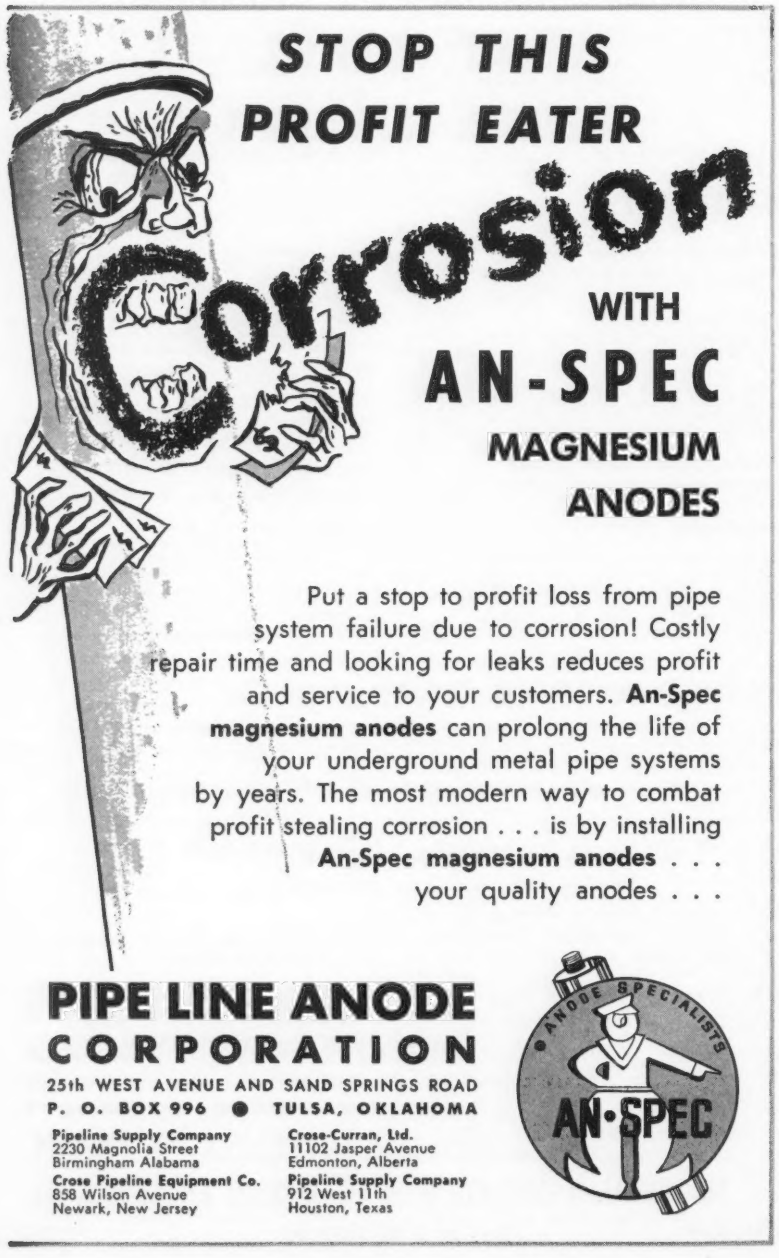
The Thermal Oxidation of Tin. R. K. HART. *Proc. Phys. Soc.* (London), (B), **65,** No. 12, 955 (1952).

Electron-diffraction studies of tin foil, heated in air with a locally applied flame, revealed that there was a gradual transition from the initial tin, through an amorphous oxide to a crystalline deposit of stannous oxide and finally to stannic oxide in the hottest region. It was found that amorphous films were formed up to ~ 130 degree C.—MA. 6796

6.3.15, 3.8.3, 2.6, 1.6

Corrosion and Passivity Studies with Titanium; Internal Technical Report (for) July 1, 1952-May 1, 1953. H. E. FARNSWORTH AND A. M. RUSSELL. Barus Research Laboratory of Physics, Brown University. May, 1953, 58 pp.

The purpose of this investigation is to attempt to correlate the adsorption of gases on titanium with the passivity of metal. The first objective is a study of the removal of the gas and of the electron diffraction patterns of the titanium crystal. The crystal structure is discussed and the electron diffraction beam calculated. The vacuum system used for degassing the titanium crystal is described in detail. The electron diffraction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beams obtained in preliminary tests are discussed and tentative conclusions are drawn.—NSA. 6309

6.3.15, 4.3.2, 4.4.2

Uniform Test Procedures Evaluate Corrosion Resistance of Titanium. G. C. KIEFER. (Allegheny Ludlum Steel Corp.) *Iron Age*, **170**, No. 23, 170-173 (1952) Dec. 4.

Unalloyed Ti 75A titanium sheet is far superior to most common metals in resistance to chemical pitting. Although less noble than stainless (Type 302) titanium shows better corrosion resistance. Corrosion tests were made in many media. In boiling nitric acid and room temperature hydrochloric acid, titanium is better than stainless but in concentrated sulfuric acid or phosphoric acid stainless is more resistant. In organic acids both metals behave similarly. Uniform surface potentials on all samples prior to test were achieved by using carbon tetrachloride degreasing followed by boiling in 20 percent sodium carbonate. Tables. —INCO. 6780

6.3.17, 6.3.21, 3.2.3, 3.8.4

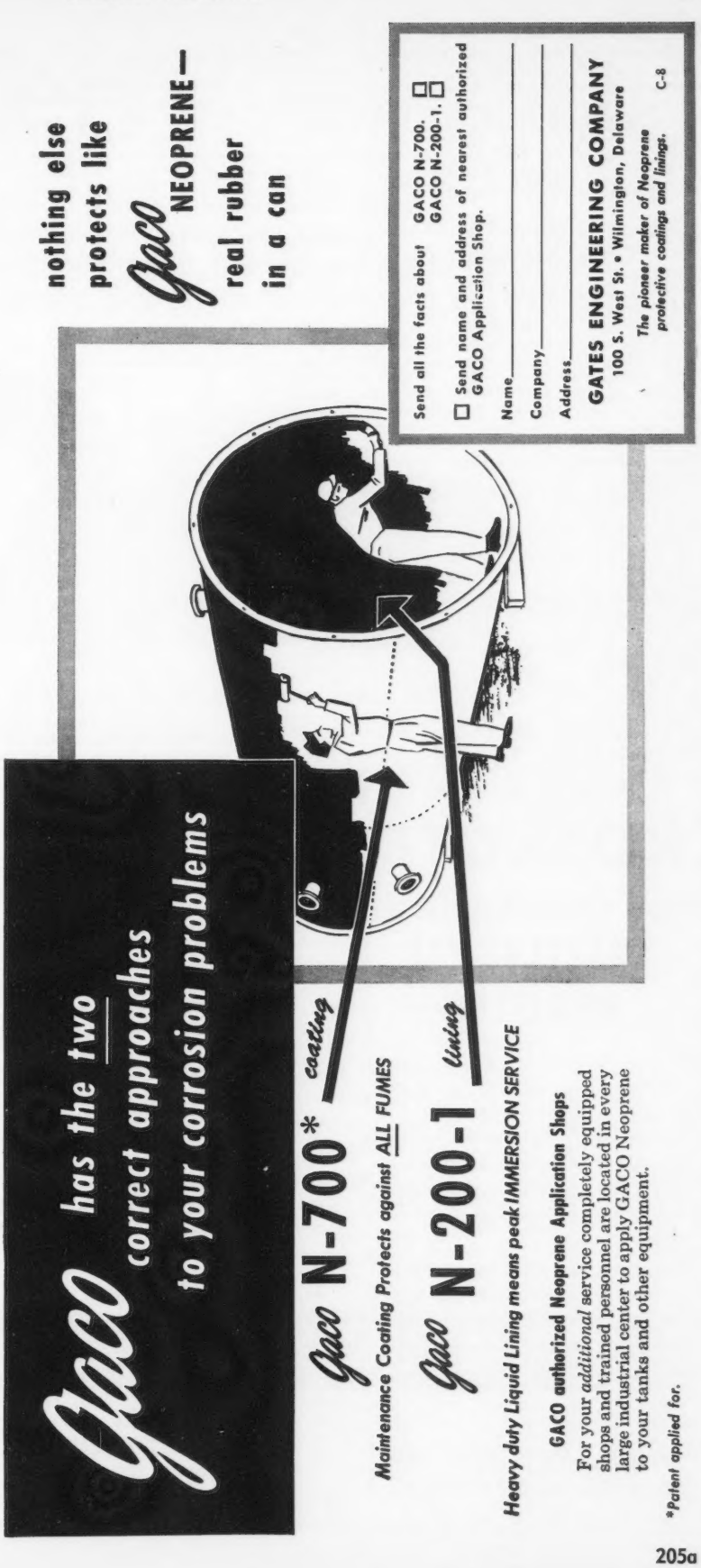
Study of Pyrophoric Metals: The Oxidation of Cerium and Uranium. JEAN LORIERS. *Rev. Met.*, **49**, Nos. 11 & 12, 801-810; 882-905 (1952).

Cerium is the base of all industrially pyrophoric alloys and since uranium, although not used industrially for this purpose, behaves similarly, Loriers experimentally investigated the phenomenon of pyrophoricity by studying the oxidation of these metals by means of mass/time curves and by determining the nature and structure of the oxides found, which should not be of a protective nature. He used differential thermal anaylsis, a sensitive thermobalance and electron or X-ray diffraction. Pyrophoricity can be conferred on any oxidizable metal. Cerium is the most pyrophoric metal, with an ignition temperature of 320 degree C in the massive state and a much lower one as powder or filings; it is little affected by the air supply, composition of the atmosphere, or rate of heating. The transformation $\beta \rightarrow \gamma$ cerium is accompanied by a short-lived but important increase. The rate of oxidation is low at room temperature, but increases abruptly between 290 and 300 degrees C. Electron diffraction disclosed a new oxide, Ce_2O_5, of the cubic system with $\alpha = 11 \cdot 26$ Å. The pyrophoricity of uranium is comparable to that of cerium, in accordance with a newly propounded law of oxidation involving a progressive alteration in the composition of the oxide layer. In oxygen the rate of oxidation starts to become appreciable at ~150 degree C and has two regions of rapid increase at 240 and 350 degree C. Ignition occurs above one or other of these two temperatures according to the form of the specimen. In air, oxidation is less rapid and combustion less violent. Below 150 degree C is the region of fcc UO_2; between 150 and 250 degree C that of U_3O_7 and above 250 degree C that of orthorhombic U_3O_8. 97 references.—MA. 6820

6.3.19

Investigations on Alloys of "Five Nines" (99.999) Zinc. (In German). W. HOFMAN, F. ERDMANN-JESNITZER AND H. HANEMANN. *Z. Metallkunde*, **43**, No. 12, 417-421 (1952) Dec.

Tensile and corrosion tests (steam at 95 degrees C) on zinc-aluminum and zinc-aluminum-copper alloys (some with magnesium added) made with zinc of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99.999 and 99.99 percent purity. Alloys made with super-purity zinc claimed to show markedly superior corrosion resistance, especially when the magnesium content was low; they showed slightly more dimensional stability but the mechanical properties were hardly altered. The "five nine" or "DK" zinc was made by the Duisberg Copper Smelter by electrolysis with molten amalgam.—BNF. 6769

6.3.19

The Surface Treatment of Zinc and Zinc Alloys. (In German). K. Bayer. *Metall*, **6**, No. 17/18, 511-513 (1952) Sept.

A general account of the main points to be observed in the finishing of zinc alloys die castings, especially by copper/nickel/chromium plating. There is also brief mention of chromating and phosphating processes and of the organic finishes that may be used. A table shows the classes of plated coatings recognized in the German standard DIN 50-964. Four copper/nickel/chromium coatings are specified, with approximately 0.0015, 0.0010, 0.0005 and 0.00025-inch of copper plus nickel. The thickest of these is only to be used in exceptional circumstances. —ZDA. 6794

6.3.19

Influence of Lead to Zinc (Zamak) Alloys for Die Casting. Nobutaro Kayama and Masakazu Ichida. Repts. Casting Research Lab., Waseda Univ., No. 3, 48-51 (1952).

Effects on aqueous corrosion resistance, thermal expansion coefficient and impact strength of zinc-aluminum-copper alloys containing 0.005-0.04% lead. Tables and graphs.—BTR. 6683

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Removal of Embrittling Gases from Zirconium. W. C. Lilliendahl, E. D. Gregory and D M. Wroughton. *J. Electrochem. Soc.*, **99**, No. 5, 187-190 (1952) May.

Removal of oxygen from zirconium by heating the solid metal in molten or gaseous calcium. At high temperatures the process may be used for removing nitrogen from calcium.—BNF. 6753

6.3.20, 6.3.13, 3.7.2, 3.2.2

Embrittlement of Zirconium and Tantalum in Hydrochloric Acid. L. B. Golden, I. R. Lane and W. L. Acherman. *Ind. and Eng. Chem.*, **45**, No. 4, 782-786 (1953) April.

Zirconium, zirconium alloys and tantalum exposed to concentrated hydrochloric acid at high temperatures in sealed glass tubes showed varying degrees of corrosion resistance, depending largely on the degree of purity or amount of alloying. Embrittlement occurring in one lot was attributed to impurity. High purity arc-melted and induction-melted (in graphite) zirconium were almost completely resistant to corrosion and showed no embrittlement at atmospheric pressure. Zirconium-niobium alloy (induction-melted) had shallow surface embrittlement, induction-melted zirconium and zirconium-tantalum had severe embrittlement and ordinary purity zirconium disintegrated under three atmospheres of pressure and 100 degrees C. Forty-six of the 103 zirconium alloys tested were corrosion resistant to concentrated hydrochloric acid at 60 degrees C while 22 were at 100 degrees C. Molybdenum, silver and magnesium alloys showed great resistance. 6311

6.3.20, 6.3.15, 3.5.8

Corrosion Studies on Titanium and Zirconium Metals: Monthly Report for April 1953. L. B. Golden, W. L. Acherman, W. Mace, D. Schlain, R. E. Heise, Jr. and D. Steele. Metals Corrosion Lab., Bureau of Mines. 1953, 11 pp.

Evaluation tests on the susceptibility of titanium, zirconium, titanium-zirconium alloys and stainless steels to stress corrosion cracking in red fuming nitric acid are reported. The results of bending samples beyond the elastic limit into a "U" shape, held under stress in a special holder and completely immersed in the acid at room temperature are given. Electrode potential measurements and galvanic couple tests indicate that titanium (arc-melted) is electronegative with respect to aluminum alloy (61ST6) in helium-aerated 0.1$\underline{N}$ sulfuric acid solution.—NSA. 6332

6.4 Non-ferrous Metals and Alloys—Light

6.4.2

Electrothermic Industries Round Table Features Electro-Chemists' Meeting. *Chem. Can.*, **4**, No. 12, 41-42 (1952) Dec.

The Electrochemical Society held its fall meeting in Montreal, October 26-30, during which 120 of the delegates visited Arvida as guests of the Aluminum Company of Canada, Limited. Eighty-one papers were presented during the conference, in the nine divisions of the society. In the Corrosion Division, discussion of a paper dealing with the flaking off of the oxide film on aluminum at elevated temperatures, brought out the probability that a concentration of the minute impurities in the metal, on the suface, under the oxide film, might be responsible for this phenomenon. J. E. Draley investigated the rapid deterioration of 2S aluminum in water at temperatures of about 250 degrees C. (test range 50-315 degrees C) and found slight increases in pH (e.g. from 5 to 2 pH) cause a great increase in the corrosion rate and that coupling the aluminum with stainless steel as the anode, greatly reduced corrosion of aluminum. Following a round table discussion on electrothermic industries in Canada, panel members gave brief résumés of the operations of the various industries represented and compared productive capacity with present and projected demand for their products in North America. Notes provided on aluminum recorded the highest production figures of all nonferrous metals.—ALL. 6817

6.4.2

Industrial Aluminium-Base Alloys. (In French). Jean Herenguel. *Rev. Met.*, **49**, No. 11, 765-776 (1952).

Herenguel classifies the wrought aluminum alloys according to their principal properties: 1) Conductivity: 99.5 percent aluminum has an electrical conductivity 62 percent that of pure copper and is used for overhead cables; Al-Mg_2Si alloy (Aldrey) (52 percent) is also used for cables; aluminum-0.8 percent magnesium alloys (50 percent) for fine wires; and aluminum-3 percent magnesium alloy (30 percent) for bars and tubes at transformer stations. 2) Corrosion-Resistance: 99.99-99.95 percent aluminum has the highest resistance to corrosion, though 99.5-99.7 percent aluminum is usually satisfactory for many purposes; aluminum-manganese (0.8-1.5 percent) alloys have been largely superseded by the aluminum-magnesium alloys (0.8-1.5 percent magnesium), which are now used extensively under a variety of conditions. 3) Cold Working: aluminum 99 percent and over is used for drawing and pressing; the aluminum-magnesium (0.8-3.5 percent magnesium) alloys are nearly as good as aluminum and are gradually replacing it; the aluminum-zinc-magnesium alloys (zinc 3, magnesium 1.75 percent) age at room temperature; the aluminum-magnesium-silicon (magnesium 1, silicon 1 percent) alloy has good corrosion-resistance but requires full heat-reatment; aluminum-copper-magnesium (copper 2, magnesium 1 percent) is used for cold driven rivets. 4) Hot Working: the aluminum-magnesium-silicon and aluminum-zinc-magnesium alloys, as above, are used. 5) Welding: the aluminum-magnesium alloys (up to 5 percent magnesium) are useful under certain conditions; the aluminum-magnesium-silicon (magnesium 0.7-0.9, silicon 0.9-1.3 percent) and aluminum-zinc-magnesium (zinc 3.5, magnesium 1.75 percent) alloys have good welding properties, the former requiring heat-treatment after welding. 6) High Strength: Duralumin and the aluminum-zinc-magnesium alloys are extensively used. 7) High-Temperature: These have additions of nickel or nickel+iron and are preferably made with 99.99 percent aluminum. 8) Free-Cutting: These are analogous to the free-cutting brasses (e.g. lead-containing). Herenguel describes the probable developments of light alloys for various purposes. 14 references.—MA. 6824

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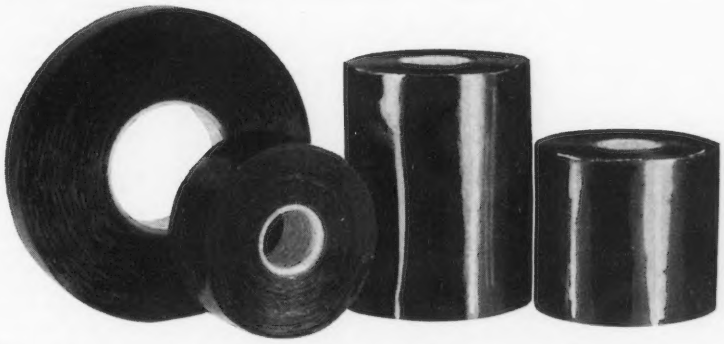

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6.4.2, 3.2.3, 3.7.2

Oxidation of Aluminium-Magnesium Alloys During Foundry Operations and the Protective Role of Small Beryllium Additions. J. CALVET AND V. POTEMKINE. *Recherche Aeronaut.*, No. 29, 21-28 (1952) Sept./Oct.

Information on the oxidation of molten aluminum-magnesium alloys and the protective effects of beryllium addition is reviewed. Experiments with melts (without beryllium addition) showed that progressive and rapid oxidation, marked by the appearance of magnesium-rich protuberances on the surface, occurred as the magnesium content was increased. The oxidation-inhibiting properties of various materials were tested and beryllium was found to be extremely effective in much smaller quantities than were hitherto considered necessary (0.2 percent), e.g. 0.007 percent beryllium gave complete protection to an aluminum-12 percent magnesium bath maintained at 780 degrees C for two hours. Calcium, iron and magnesium were also effective, but to a very much lesser degree. Finally, the protective role of beryllium in preventing the oxidation of aluminum-magnesium alloy cast in metal or green sand molds was studied, as well as beryllium losses incurred by agitation of the surface of the molten metal bath and chlorination. The latter caused appreciable beryllium loss.—MA. 6695

7. EQUIPMENT

7.1 Engines, Bearings and Turbines

7.1, 3.5.3

Cavitation in Journal Bearings. H. L. MCBROOM. *Sci. Lubrication*, **1953**, 10-15, April.

Investigation described provides, on a small scale, a more definite indication of certain primary effects of cavitation in the lubricated bearing. Pressure conditions in divergent part of film, as postulated in some recent theoretical analyses, are not confirmed by experiments.—INCO. 6540

7.1, 8.9.4, 3.5.3, 5.8.2

Symposium on Diesel Locomotive Engine Maintenance. 1953, 146 pp. American Locomotive Company, Public Relations Department, Schenectady 5, N. Y. Free

Contains the following papers presented at a meeting at Schenectady May 11 & 12, 1953: Progress Report on Spectroscopy, which consisted of reports on the experience of nine railroads reported by their representatives. Consensus is that spectroscopic analysis of lubricating oil permits operators to be warned in advance of coming mechanical trouble. Some unexplained erratic reports are cited. Other papers are Comparative Laboratory Results; A Report on Comparative Spectrographic Laboratory, The Control of Railroad Lubricating Oils, Mixing of Lubricating Oils, Reclaiming Used Diesel Engine Crankcase Oils, Lubricating Oil Control Testing Methods (six parts), Lubricating Oil Filtering and Filtering Media, The Electron Microscope, Air Filtration, Maintenance of Air Filters (four parts), Air Filter Coating Oils, Birmingham Southern Experiences with Filters and Oils, Diesel Engine Cooling Water Treatment with Non-Chromate Compounds and Diesel System Cooling Treatment.

The last two papers deal with the history of cavitation erosion and with the use of chromates. Tests are reported underway using borates, nitrates, silicates, soap, mercapto-thiozoles, sodium carbonate, sodium phosphate and others.

The last paper mentions satisfactory experience with chromate inhibitors to prevent erosion and corrosion of liners. Tests on one non-chromate inhibitor showed it effective in limiting corrosion on one type of engine but not on another. An improved non-chromate is being tested now. Principal objection to chromate treatment is in the dermatitis it causes. 6593

7.2 Valves, Pipes and Meters

7.2, 6.6.8, 2.2.7, 2.2.3

Progress on Naval Use of Reinforced Plastic Piping. A. M. MCKENZIE and H. J. STARK. *J. Am. Soc. Naval Engrs.*, **65**, No. 1, 57-70 (1953) Feb.

U. S. Plywood Corporation's investigation of glass fiber reinforced thermosetting resin plastic piping is discussed. Large-scale corrosion-erosion tests were performed on the assembled plastic piping system at Kure Beach. The Industrial Test Lab. evaluated the performance of reinforced plastic, aluminum and copper-nickel alloy piping when exposed to large-scale fires. Effect of weather on bonding of joints and the shipboard trial are discussed. Reinforced-plastic tubing is expected to become competitive with steel pipe as improved methods of manufacture and increased usage come into being. Photographs and references.—INCO. 6377

7.2, 5.3.2, 4.2.5

Fighting Corrosion at a Gulf Coast Terminus by Metallizing with Zinc. F. L. RESEN. *Oil Gas J.*, **52**, No. 7, 273-274 (1953) June 22.

Pipeline installations on Mustang Island in Outer Corpus Christi Bay were metallized with zinc by United Gas Pipe Line Co. as a means of combating corrosion in this Gulf Coast locality. Exposed piping and valves are subjected to salt-water spray together with being exposed to relatively high atmospheric temperatures. The zinc layer was covered with a vinyl coating for further protection.—INCO. 6624

7.2, 6.6.8, 4.5.1, 4.6.6

Plastic Pipe: What's Its Future? *Eng. News-Record*, **150**, No. 19, 37-38, 41 (1953) May 7.

Sections of the first installation of plastic pipe in the water system of Pontiac, Michigan were dug up recently and after two years showed no signs of corrosion either inside or out. There was some damage at coupling points, but Pontiac now has installed bronze fittings that are expected to solve this problem.—INCO. 6470

7.3 Pumps, Compressors, Propellers and Impellers

7.3, 3.5.3

Materials for Central Station Pumps. J. B. GODSHALL. *Corrosion*, **10**, No. 1 21-24 (1954) Jan.

Increased temperature, pressure and purity of central-station feedwater causes corrosion-erosion in feed pumps. Studies by operators, pump manufacturers and technical groups have led to certain conclusions: 1. Reducing corrosion by modifying the water is rarely feasible. 2. Materials must be used which resist corrosion-erosion. 3. Cast iron and carbon steel are generally unsuitable. 4. Five percent chromium steels prevent corrosion-erosion. Higher alloy concentrations do not provide a marked improvement. Relative service life is about 1 for iron and steel, 10 to 90 for 1% chromium steel, 100 for 5.% chromium steel, 100 to 105 for 13.% chromium steel and 100 to 150 for 18/8. General use of chromium steels presents manufacturing problems. Clearances must be adjusted and different materials and/or hardnesses are important to prevent seizure. Preheating and stress-relief annealing are important after welding. Stainless or "K" Monel shafts are recommended.

Heater drip pumps need all-bronze or 13.% chromium steel construction if dissolved gases are present. If there is no contamination, or if the temperature is low as in the case of condensate pumps, iron or steel casings with bronze impellers are used. Circulating pump materials vary with the water quality.

Cast iron casings and bronze impellers are typical for fresh water. For sea and harbor waters all-bronze construction is desirable. With polluted harbor waters, stainless steel impellers in bronze casings are sometimes necessary. Commercial considerations sometimes dictate the use of cast iron casings for very large circulating pumps. For the corrosive applications, Monel or stainless shafts are recommended to prevent failures by corrosion fatigue.

7.3, 4.6.7

Corrosion of Ships Propellers in Polluted Estuaries. A. B. WHEATLAND and A. LAIRD. *Engineering*, **175**, 532 (1953) April 24.

Letter giving brief report of experiments by Water Pollution Research Laboratory on propellers and propeller parts of gun-metal and phosphor-bronze which showed injurious effects resulting from pollution of estuaries. In the water concerned, sulfide is known to be present during the summer months and it is concluded that its presence is responsible for reversal of potential and that it might cause the excessive corrosion of the copper alloys which had been noted.—INCO. 6608

7.3

Pump Materials That Can Reduce Corrosion. R. J. MACMEEKIN. *Industry and Power*, **63**, 97-98 (1952) Nov.

Presents characteristics of various metals and stresses combinations applicable for special conditions met in actual operation. Table.—BTR. 6792

7.3, 3.6.2

A Study on Causes of Surface Damages on Ship Propellers. E. GALTUNG. *J. Am. Soc. Naval Engrs.*, **65**, No. 2, 389-399 (1953) May.

Potential differences are set up on a propeller blade without cavitation and the magnitude of the potential differences might be sufficient to initiate corrosion. If cavitation is present, the oxide film ought to be of a type that is not easily dragged away from the surface and it ought to be tight in order to prevent electrolysis between the metal and the surface oxide layer. A smooth surface will help to avoid initial differential aeration (oxidation) at the top and bottom of scratches and at the bottom

and edges of holes. Most resistant materials are copper-nickel alloys, the aluminum bronzes and the high tensile brasses. 16 references.—INCO. 6334

7.5 Containers

7.5.5

New Method of Rehabilitating Cone-Roof Storage Tanks. R. T. EFFINGER AND D. G. WEBB. Shell Oil Co. *Oil Gas J.*, **51**, No. 32, 100-101, 128 (1952) Dec. 15.

Improved technique for repairing corroded tanks includes removing an upper course, cutting the tank away from the base, jacking it up and installing a new bottom course. Because of the graduated thicknesses of successive shell courses, this method in effect upgrades each intermediate course. Scarce tank steel is thereby conserved.—INCO. 6655

7.5.5, 4.6.7, 5.3.2, 5.8.2, 2.2.7

Corrosion of Galvanized Iron Tanks. *Chemistry and Industry*, No. 34, 825 (1952) Aug. 23.

Australian tests have shown that corrosion of new galvanized rainwater tanks, caused by very pure water, can be prevented by suspending a galvanized gauze tube containing glassy metaphosphates in the water. The mixture used consists of quickly-soluble zinc metaphosphate and slowly-soluble zinc calcium metaphosphate. 21-month field tests at two places showed that protective films were formed in all the tanks treated. Many untreated controls suffered severe corrosion and rusting.—ZDA. 6315

7.6 Unit Process Equipment

7.6.4, 4.3.3

Vanadium Ash Problems in Oil Fired Boilers. F. E. CLARKE. *J. Am. Soc. Naval Engrs.*, **65**, No. 2, 253-270 (1953) May.

Case history has demonstrated that fuel ash constituents can promote a variety of serious fireside problems in boilers in the absence of sea water contamination. An interesting study of vanadium deposits and the many problems regarding their reactions are covered. The vanadium compounds are major constituents of all of the fireside deposits. Minor constituents like the compounds of calcium, magnesium, nickel, chromium, lead and iron are present in most of the deposits. Variation in proportion of major constituents in different parts of the furnace suggests selective deposition related to furnace temperature gradients, combustion characteristics or ash properties. Tables and illustrations. —INCO. 6261

7.6.4, 4.6.2

Boiler Tube Failures. E. S. RIVETT. *Modern Power and Eng.*, **47**, No. 2, 84-86 (1953) Feb.

A discussion of common tube troubles with some of their causes which includes corrosion due to acidity or the action of oxygen or carbon dioxide in boiler water, caustic embrittlement due to caustic alkalinity in the boiler water, damage to tube ends through overrolling, erosion of the outside of the tubes by soot-blower jets, erosion caused by slag formation and partial blanketing on the front row of a bank of tubes, and bagged tubes caused by a layer of hard scale in the tube. Preventive measures are given. Illustrations.—INCO. 6128

7.6.4, 4.6.2

How to Care for Unit Heaters. *Heating, Piping, Air Conditioning*, **24**, No. 5, 96-98 (1952) May.

Industrial Unit Heater Association gives practical suggestions on the care and maintenance of steam and hot water unit heaters. The chief cause of corrosion in the tubes of unit heaters and in the connecting return lines is carbon dioxide which, with condensate, forms carbonic acid. This carbon dioxide can be removed or neutralized by the use of a deaerating feed-water heater, employing the blend system, acid treatment system, and degasifier or demineralizing system. Volatile alkalies may also be added internally to control carbon dioxide corrosion. Diagrams.—INCO. 5957

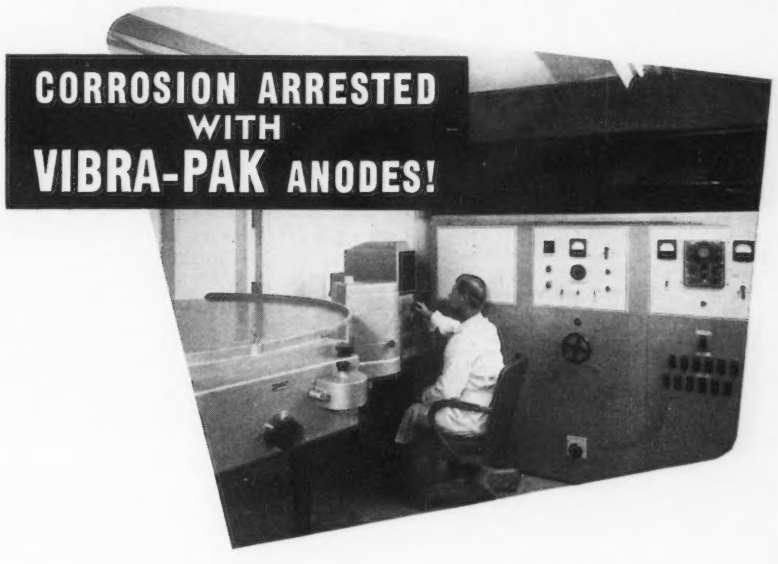
7.6.6, 8.5.3

Review and Summary of Some Principal TAPPI Papers. Papers before TAPPI, 38th Ann. Mtg., New York City, Feb. 16-19, 1953. *Paper Trade J.*, **136**, No. 8, 104 (1953) Feb. 20.

Papers include: "Uneven Corrosion in Alkaline Pulping Digesters—A Major Cause and Possible Cures," F. W. Flynn, F. B. Snyder and F. H. Richter (Crown Zellerbach Corp.); "Some Observations on the Causes and Prevention of Kraft Digester Corrosion," E. W. Hopper (Crucible Steel Co. of America); "Experiences with Field Applied Inconel Digester Linings," S. J. Baisch (Thelmany Pulp & Paper). Prevention measures taken to control corrosion in digesters are discussed.—INCO. 6157

7.6.6, 8.5.3

Kraft Mill Corrosion. C. B. CHRISTIANSEN. Paper before Can. Pulp & Paper



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Assn., Saranac Lake, June 4-6, 1953. *Paper Trade J.*, **136**, No. 24, 19-20 (1953) June 12.

Aspects of alkaline pulp mill corrosion are discussed. Two sets of forces result in the corrosion of digester steel. One set combines to form primary corrosion resulting from the interaction of wood, liquor, and steel during the cooking process. Secondary effects are superimposed on the first, owing to the presence of scale, uniformity of steel, fabrication methods, digester design, and operating practices. These tend to accentuate and localize the attack in some areas, determining the major corrosion patterns found in digesters.—INCO. 6269

7.6.9, 8.8.1, 1.2.5, 4.4.2

Operation of Vinegar Generators. R. J. ALLGEIER, R. T. WISTHOFF, AND F. M. HILDEBRANDT. Nat'l Distillers Corp. *Ind. and Eng. Chem.*, **45**, No. 2, 489-494 (1953) Feb.

Study of S.D.35A, regular and special, S.D.18, S.D.29, and 190-proof undenatured ethyl alcohol as feed for the production of acetic acid in Frings-type generators. An investigation on the effect of heavy metals on the activity of vinegar generators shows that the relative toxicity rating of the metals tested is in the order of lead, copper, iron, zinc and tin. It is suggested that tin, chromium, nickel, steel and other high-silicon iron alloys are best for vinegar installations. Illustrations, 5 references.—INCO. 6241

7.7 Electrical-Telephone and Radio

7.7, 5.4.5

Weathering and Crack Resistance of Black Polyethylene for Wire and Cable. W. A. HAINE, E. F. AND N. R. SMITH. *Elec. Eng.*, **71**, 1113-1117 (1952).

Polyethylene has outstanding dielectric properties and low-temperature flexibility but its susceptibility to ultraviolet radiation has prevented its application as outdoor protective coating. This difficulty can be overcome by adding small concentrations of a medium channel carbon black.—RPI. 6786

7.7, 6.3.8

Positive-Grid Corrosion in the Lead-Acid Cell: Corrosion Rates of Tin Alloys and the Effect of Acid Concentration on Corrosion. J. J. LANDER AND J. B. BURBANK. Dept. of Navy, Naval Research Lab., Report No. 5078, Nov. 7, 1952, 25 pp.

Corrosion and growth rates of several binary and ternary lead alloys were measured under anodic conditions. An empirical relationship between growth and tensile strength is shown. Binary tin alloys exhibit lower corrosion rates than calcium and antimony alloys and ternary tin alloys show both less corrosion and smaller growth rates. Positive plate growth is correlated with capacity vs life data for cells having 8 and 9 antimonial grids. Results of weight loss measurements and microscopic examination of corroded grids from life-tested batteries having electrolytes of different concentration further clarify the concentration effect on corrosion. Illustrations and references.—INCO. 6752

7.7, 6.4.2

Aluminum as a Cable Sheathing Material. D. MCALLISTER. *Engineer*, **194**, 819-823; 854-857 (1952) Dec. 19, Dec. 26.

Gives details of new techniques which were developed for sheathing and handling cables, together with an account of general properties of aluminum sheaths. Includes advantages and disadvantages of aluminum, production of aluminum and extrusion. Presents general properties of aluminum sheaths, ease of installation, process of jointing and resistance to corrosion. Diagrams and photographs. 15 references.—BTR. 6806

7.7, 8.2.1, 8.2.2

Solving Problems in Materials. T. S. FULLER. *ASTM Bull.*, **1952**, 51-62, Oct.

Outlines progress in materials which has contributed to advancement in the electrical industry during past 50 years. Considers copper, copper with silver and cadmium, supply of copper, permanent magnets, ferritic steels, ultrasonic testing and oil ash corrosion. Includes failure and stress of materials. Micrographs and graphs.—BTR. 6704

8. INDUSTRIES

8.1 Group 1

8.1.2, 4.2.4, 4.2.5, 4.2.6

The Atmospheric Corrosion of Architectural Metals. HUGH P. GODARD. *Eng. J.* (Canada), **36**, No. 7, 844-855 (1953) July.

This paper, which was presented before the 67th Annual General and Professional Meeting of the Engineering Institute of Canada, Halifax, N. S., May, 1953, discussed the atmospheric corrosion of the metals commonly used in building—aluminum, copper, lead, steel, zinc and galvanized steel. It is based largely on the reports of Committees A-5 and B-3 of the ASTM and the Corrosion Committee of the British Iron and Steel Research Association. Results of short-time tests from the atmospheric exposure program of Aluminum Laboratories Limited are included. The corrosion rates of the various metals in rural, marine, industrial and industrial-marine atmospheres are compared, using the rate of thinning, expressed as mils per year (mpy) as the unit of comparison.—ALL. 6325

8.1.4, 5.8.2, 4.6.6

Corrosion Control in Potable Water Systems. ROLF ELIASSEN. Massachusetts Institute of Technology, Cambridge. *Water & Sewage Works*, Ref. and Data Ed., **99**, No. 4, R79-R81 (1952).

Based on country-wide experience, corrosion in potable water distribution systems can be effectively controlled by dosing corrosive waters with either sodium silicate, a polyphosphate, or a mixture of these.

The preferred initial dosage of sodium silicate is 12-16 ppm at a pH of 8-10.6. As soon as a protective silicate film starts forming in the remote parts of the distribution system, usually after one month, the dosage can be reduced to 4-8 ppm and regulated so that at least one ppm above the natural silica content of the water is present at the far end of the system.

Suitable polyphosphates include sodium hexametaphosphate, sodium heptaphosphate and tetrasodium pyrophosphate. The recommended initial dosage is 6-12 ppm at pH 5.2-10.6. Final dosage after formation of a protective film is 2-6 ppm with the dosage regulated to insure at least 0.5 ppm at the end of the distribution system. Good results have been obtained with 2-4 ppm polyphosphate together with 8-12 ppm silicate in corrosive waters that have not responded to either reagent alone. Systems in which water is heated to 185 degrees F usually require higher dosages, because the corrosion of ferrous metals by water in an open system is usually maximum at temperatures of about 176 degrees F.

To insure a continuous protective coating at all times, continuous proportionate feeding of the protective chemical to the system and frequent testing of the water at the end of the system is necessary. It is also advisable to insert test loops of piping at strategic points in the system for periodic inspections.

Because dissolved oxygen is the principal promoter of corrosion of ferrous metals in water systems, particularly at elevated temperatures, corrosion can be controlled by deaerating the water by application of heat or vacuum or both, or by passing the water over beds of scrap iron or steel (deactivation process). However, these methods are not economical in large water distribution systems.—PDA. 6821

8.2 Group 2

8.2.2, 4.6.2

Feedwater Handling is Planned in Illinois State Power Plants. R. W. LANE. Ill. State Water Survey. *Power Eng.*, **56**, No. 11, 91-93+ (1952) Nov.

Unified program of feedwater treatment in Illinois State power plants resulted in complete acceptance by engineers, virtually no corrosion or scale and overall increased plant efficiency. Close attention was directed toward the regeneration of zeolite softeners and to the control of the lime-soda treatment. Efficient deaeration was found to be of importance in the control of corrosion in the preboiler system, boiler proper and condensate return lines. Sodium sulfite, neutralizing and filming amine type treatments were also given consideration. Graphs, tables and 13 references.—INCO. 6811

8.4 Group 4

8.4.3

Midland Farms, Texas, Reaches Major-Field Status. J. A. KORNFELD, *Oil Gas J.*, **52**, No. 4, 88-91 (1953) June 1.

At Midland oil fields, discovered by Stanolind, increased water production accelerated corrosion. Hydrogen sulfide corrosion effects were observed as pitting on tubing and rods and the formation of a black, iron sulfide scale. Rods failed due to hydrogen embrittlement as well as fatigue. To mitigate corrosion, wells were treated with either a water soluble inhibitor such as formaldehyde or an oil-soluble commercial inhibitor. To mitigate external casing corrosion, Stanolind used cathodic protection; magnesium anode beds were installed. Tables. —INCO. 6736

8.4.3, 5.9.2

Chemical Cleaning of Refining Equipment. G. L. FARRAR. *Oil Gas J.*, **51**, No. 46, 211-212+ (1953) Mar. 23.

Removal of surface scale, deposits and impurities from metals by immersion in

two-way abilities

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acid or other suitable solvent is commercially feasible. Additions of inhibitors prevent attack of the base metal, but permit rapid solution of the scale. Oxidizing agents, such as chromates, some copper compounds, manganese dioxide and ferric iron compounds tend to increase the rate of metal corrosion by the solvent. Tests should be made to determine whether these effects are appreciable and if so, precaution should be taken during the cleaning period. Stainless steels may be cleaned with inhibited acids and nickel and its alloys may be cleaned with non-oxidizing acids. Case histories are cited.—INCO. 6324

8.4.3, 2.3.2, 3.4.8

Estimating the Corrosivity of Crude Oils. H. A. CATALDI (Standard Oil Co.) R. J. ASKEVOLD, AND A. E. HARNSBERGER (Pure Oil Co.). Paper before API, Mid-Year Mtg., Div. Ref., N. Y., May 12, 1953. *Oil Gas J.*, **52,** No. 11, 100, 103-104 (1953) July 20; *Petroleum Refiner,* **32,** No. 7, 145-150 (1953) July.

API Committee reports the results of its studies to find an accurate, reliable method for predicting crude oil corrosivity in refining equipment. Efforts of the group were directed to corrosion at temperatures in excess of 600 degrees F and two methods of attack are considered. Indiana method is based on the change in the electrical resistance of a specimen, the change resulting from the loss of metal by exposure to a corrosive medium. Table gives assigned degree of corrosiveness, the results of analyses for total sulfur and for acidity for various oils. An evaluation of the vapor-phase corrosivity was secured simultaneously with the liquid-phase corrosivity. Pure Oil method is directed specifically to the corrosive effect of sulfur compounds under conditions of high temperature and pressure. Experiments were carried out to measure the quantity of hydrogen sulfide released from various crude oils and the results are tabulated.—INCO. 6343

8.4.3, 4.6.11

How Bahrein Petroleum Combats Sea-Water Corrosion at Persian Gulf Installations. R. L. DAVIS AND R. F. HEINZERLING. Calif. Texas Oil Co., Ltd. *Oil Gas J.*, **51,** No. 33, 264, 266, 268 (1952) Dec. 22.

Mild steel exposed to sea water spray at the high atmospheric humidity and temperatures encountered in the Persian Gulf corrode and pit at a very high rate. By minimizing spray, as was accomplished at Bahrein by raising some sections of lines or by building a breakwater, corrosion can be reduced to a rate where protection by paint or cutback asphalt is practicable. All submerged lines are cathodically protected. —INCO. 6701

8.5 Group 5

8.5.3

Corrosion-Resistant Metals for Pulp and Paper Industry. D. L. HORIGAN. Lukenweld. *Paper Trade J.*, **135,** No. 20, 261-262, 264-271 (1952) Nov. 14.

First part deals briefly with the types of corrosion which are apt to be encountered in pulp and paper mills: general attack, galvanic, pitting, intergranular corrosion, stress, crevice, erosion-corrosion and cavitation. Second part discusses the properties of various corrosion-resistant metals Monel, nickel, Inconel and stainless steels and the forms in which these metals are available. Part three discusses specific applications of these metals in pulp manufacture, groundwood pulp, sulfate pulp, sulfite pulp, stock preparations, Fourdrinier machine, cylinder machine and coating and sizing equipment. Graphs and photomicrographs. —INCO. 6763

8.5.3

Stock Preparation. F. HERBOLZHEIMER, JR. Scott Paper Co. *Paper Trade J.*, **135,** No. 20, 290+ (1952) Nov. 14.

Stainless steels and Monel are used for bars in beatnig equipment. These materials replace steel and bronze which are susceptible to corrosion. Diagrams. —INCO. 6765

8.5.3

Corrosion in the Pulp and Paper Industry. F. A. GUBA. Carpenter Steel Co. *TAPPI,* **36,** No. 5, 134A-137A (1953) May.

Discussion on chemicals such as acids, general, galvanic, pit-type, intergranular and stress corrosion in the pulp and paper industry. Materials considered include 5, 12 and 17 percent chromium, 18-8, 18 percent chromium-10-12 percent nickel-2½ percent molybdenum, 25 percent chromium-12 percent nickel, 25 percent chromium-20 percent nickel, Types 310, 309, 316, 304, 430, 410, 502, 443, and 329 stainless steels, Alloy C, titanium, Alloy B, Inconel, nickel, Monel, copper-nickel, copper, bronze, brass, Carpenter 20 (29 percent nickel), Carpenter B (60 percent nickel), Carpenter C (55 percent nickel), chromium-nickel-iron alloys and carbon steel. A galvanic series of metals and alloys, including steel, cast iron, chromium-iron, 18-8 chromium-nickel-iron, 18-8-3 chromium-nickel-molybdenum-iron, Carpenter stainless No. 20, nickel, copper-nickel alloys and platinum is given.—INCO. 6331

8.6 Group 6

8.6.2, 8.3.5

Use of Stainless and Acid-Resistant Steels in Edible Fats, Soap and Synthetic Detergent Industries. H. BRUAN. *Fette u. Seifen,* **53,** 641-644 (1951), *Werkstoffe u. Korrosion,* **3,** 221 (1952) May-June.

Describes properties and potentialities of chromium-and nickel-chromium steels with special emphasis on economic aspects. Resistance of these steels to nitric and sulfuric acids and to sulfuric acid-copper sulfate solutions at various temperatures and behavior of various material in hot stearic acid are given. Copper is attacked at 150 degrees C, 17 percent chromium steel loses some of its corrosion-resistance at 160 degrees C, aluminum is resistant up to 190 degrees C, and 18/8 is resistant up to about 210 degrees C. Limit of corrosion-resistance of 18/10/2 chromium-nickel-molybdenum should be somewhat higher.—INCO. 6721

8.8 Group 8

8.8.1

Chlorine and Caustic in Italy. R. L. KENYON AND P. GALLONE. *Ind. and Eng. Chem.*, **45,** No. 6, 1162-1172 (1953) June.

A discussion on the manufacture of chlorine by electrolysis of sodium chloride in the mercury amalgam cell, with special reference to the de Nora cell. The electrolyte for the amalgam cell which is a substantially saturated solution of sodium chloride should be pure in the ideal case. Chromium, nickel, vanadium and heavy metals in general are very harmful to amalgam stability. Materials of construction include steel, carbon and stainless steel and cast and cast silicon iron. Illustrations, flow sheets, 17 references.—INCO. 6727

8.8.1

Carboxymethylcellulose. R. N. HADER, W. F. WALDECK AND F. W. SMITH. Wyandotte Chem. Corp. *Ind. and Eng. Chem.*, **44,** No. 12, 2803-2312 (1952) Dec.

Carbon steel and Type 316 stainless steel are the principal materials of construction throughout the Wyandotte installation for the production of carboxymethylcellulose. Small amounts of Monel, Durichlor, Saran-lined pipe and chemical stoneware are in use in the system. In the preparation of concentrated monochloroacetic acid solution, Hastelloy is used to prevent corrosive attack. Tables, flow sheet and 10 references.—INCO. 6771

8.8.1

New Nitrophosphate Process. *Chem. Eng.*, **60,** No. 8, 115-116 (1953) Aug.

Feature of new process for making nitrophosphate fertilizers is the use of carbon dioxide to convert corrosive, unstable and hygroscopic calcium nitrate into calcium carbonate. Until 1948, the German plant used a mixture of nitric acid plus sulfuric acid for acidulation of phosphate rock. This caused corrosion of stainless steel equipment. Acidulation with nitric acaid alone solved this problem. Flowsheet.—INCO. 6320

8.8.1, 6.2.5, 5.3.2

Stainless Steel in Chemical Plant. A. M. HUTCHESON. Paper before Instn. Chem. Engrs., Birmingham, May 3, 1952. *Trans. Inst. Chem. Engrs.*, 30, No. 3 176-186; disc., 187-188 (1952).

The metallurgy of stainless steel is reviewed. The more important considerations in the design of certain units, such as cylindrical tank, supports, pressure and vacuum tanks and jacketed vessels and advantages and limitations of stainless-clad material are discussed. 15 references.—INCO. 6790

8.8.1, 7.6.5

High-Vacuum Concentration: Its Realm in the Chemical Industry. *Chemical Eng. Progress,* **48,** 589-593; disc., 593 (1952) Dec.

Deals with reduction of corrosion and scale problems as found in concentration processes in the chemical industry. Treats the reduction of scale formation by lowering of temperature and pressure and investigates possibility of material substitutions due either to corrosive properties or to strength of materials. Graphs and diagrams.—BTR. 6681

8.8.3

Materials of Construction for Plating Rooms. R. E. HARR. Western Elec. Co. Paper before AES, 39th. Ann. Conv., Chicago. June 16-19, 1952. *Proc. Am. Electroplaters' Soc.*, **39,** 119-125 (1952).

Materials of construction used in Western Electric's plating installation at the new Indianapolis plant, where the principal product is telephone sets, are reviewed. The electroplated finishes of telephone sets are zinc, nickel, copper-

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nickel, copper-tin, silver, chromium and gold. For plating room drainage, an alloy containing 20% chromium, 29% nickel, 3% copper, 2% molybdenum and 1% silicon is used. The storage tank and piping system for nitric acid are made of 18-8. Exhaust ducts of rubber-covered steel, cast phenolic resins or asphalt-impregnated transits are required in severely corrosive conditions, while steel ducts lined with spray grade gilsonite asphalt resin-base coatings are adequate for most plating room conditions. Tanks of stainless steel, Monel or polyester resin reinforced with Fiberglas are used for hot rinsing. Tables. —INCO. 6801

8.9 Group 9

8.9.1

Corrosion Proofing Grumman War Planes. FRANK L. BONEM. *Products Finishing*, **17**, No. 3, 24-32 + (1952) December.

Surface finishing of the U.S. Navy F9F Panther jet aircraft is especially important since at the sonic and supersonic speeds attained by this airplane extremely high impact forces are produced as the plane travels through the static air. Other forces affecting the finish are dust abrasion caused by solid particles of industrial waste products, coral or other dusts and air friction which at high speeds raises the temperature of the metal to such heights as to endanger the paint finish. U.S. Navy Specifications for finishing these aircraft provides: 1) Aluminum Alloys: Anodize (AN-QQ-A696) or chemical treatment (MIL-C-5541) except as follows: Seaplane exteriors must be anodized; 5% chromic acid anodizing is permitted on 2S, 3S, 52S, 61S and Clad. 2) Magnesium Alloys: One of treatments described in Specification MIL-M-3171. For paint protective systems different numbers of coats of zinc chromate primer MIL-P-6889, lacquer AN-L-29, or MIL-L-6805, enamel or varnish MIL-E-5556, MIL-V-6894 and Coating Permanent Resin MIL-R-3043 are specified for various interior and exterior surfaces. Tanks used in the finishing departments are made of mild steel, aluminum painted on the outside. For the "Alodine" dip the tank has an exhaust duct along the upper edge through which all fumes are withdrawn and is lined with Koroseal to resist corrosion. Drainage flows from the last water rinse tank back to the first, thus re-using and saving a considerable amount of water. Temperatures are controlled automatically. Cycle time is controlled by the hoist operator with the timer on the hoist switch. Racks, from which the parts are hung, have lugs which fit the edges of the tanks. They are moved through the processing cycle by an overhead electric hoist running on two I-beams. Parts that can conveniently be suspended from an overhead monorail conveyor are alodized in a spray installation. The processing methods and solutions used in alodizing are given. Chromic acid anodizing is used where anodizing is required. Following alodizing or anodizing, parts are inspected and receive a zinc chromate primer. After the planes are completely assembled they are rubbed down with a thinner and moved to huge water curtain spray booths. A second primer, also zinc chromate, is applied and the planes are finished by receiving two coats of lacquer with spray guns. There is also a plating department, which at present is set up for cadmium plating but can be readily converted to other processes such as zinc plating.—ALL. 6818

8.9.1, 5.8.2

Inhibitor Eliminates Corrosive Action on Aluminum Tubing. *Am. Metal Market*, **59**, No. 231, 9 (1952) Dec. 3.

The Aviation Department of Walter Kidde and Company, New York, is using an inhibitor which eliminates the corrosive effect of fire extinguishing liquid on aluminum tubing, through chemical stabilization. Formerly, after an airplane engine's fire extinguishing system had been used, low points in the aluminum tubing could be corroded through in a few hours.—ALL. 6729

8.9.1, 6.4.4, 5.4.5

Magnesium Finishes for Aircraft Evaluated. HOWARD D. CHILDERS. *Iron Age*, **170**, 157-161 (1952) Dec. 4.

Magnesium finishes for production applications were evaluated. The goal of obtaining better protection with less paint was accomplished. Several pigmented vinyl-type primers gave 2-3 times more protection than that of the present system. Diagrams, tables and photographs.—BTR. 6741

8.9.3

The Story of Platte Pipe Line: Details of Design and Construction. MELVIN M. LEE. *Oil Gas J.*, **51**, 109, 111 (1952) Dec. 1.

Outlines process of laying a 20-inch pipeline and problems encountered. Included are welding by electric shielded arc, X-ray inspection, coatings applied to pipe, cathodic protection and testing to determine leaks in pipes.—BTR. 6749

8.9.4

Railway Finishing Problems. T. M. HERBERT. *Paint Manuf.*, **22**, No. 8, 281 (1952).

Paint exposure trials carried out by British Railways have resulted in a durable paint system for coaches based on 8 coats as against the 17 coats used formerly. The use of controlled-chalking titanium dioxide paints on signals, etc., results in their remaining visible for longer periods before repainting.—RPI. 6782

8.9.5, 5.6.2, 5.7.4

Preservation of Floating Cranes for Government Stockpiling. R. RAYMOND EWART. *Corrosion*, **10**, No. 1 (News Section), 1 (1954) Jan.

Methods by which large floating cranes are prepared for indefinite storage are described. These included cocooning, application of coatings and installation of dehydration systems and substances. 6793

8.9.5, 6.6.8

Puget Sound Naval Shipyard Develops New 36-Foot Plastic Landing Craft. H. E. JACKSON. *Marine Eng.*, 57, No. 10, 82-5 (1952) Oct.

New plastic boat capable of carrying 36 men fully equipped or 8 tons of supplies at a speed of 12 knots, now being produced in limited quantities for use by the fleet, is built not only in one piece without seams but it is claimed to be unsinkable, long lived, impervious to corrosion and requires no painting. Photographs—INCO. 6663

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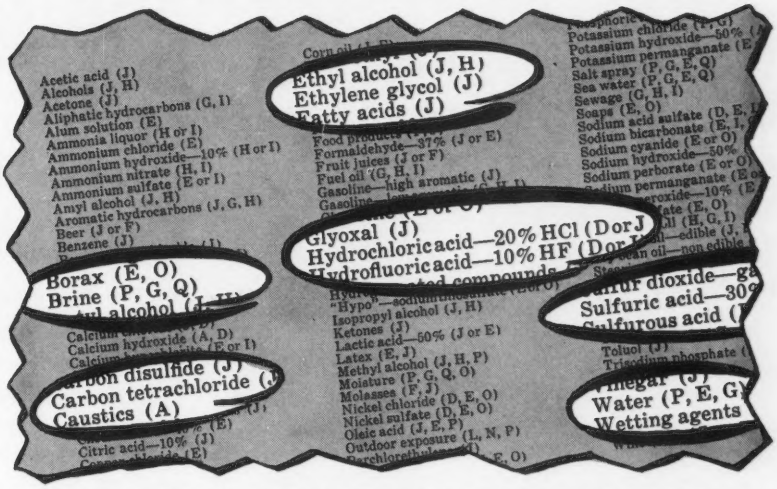

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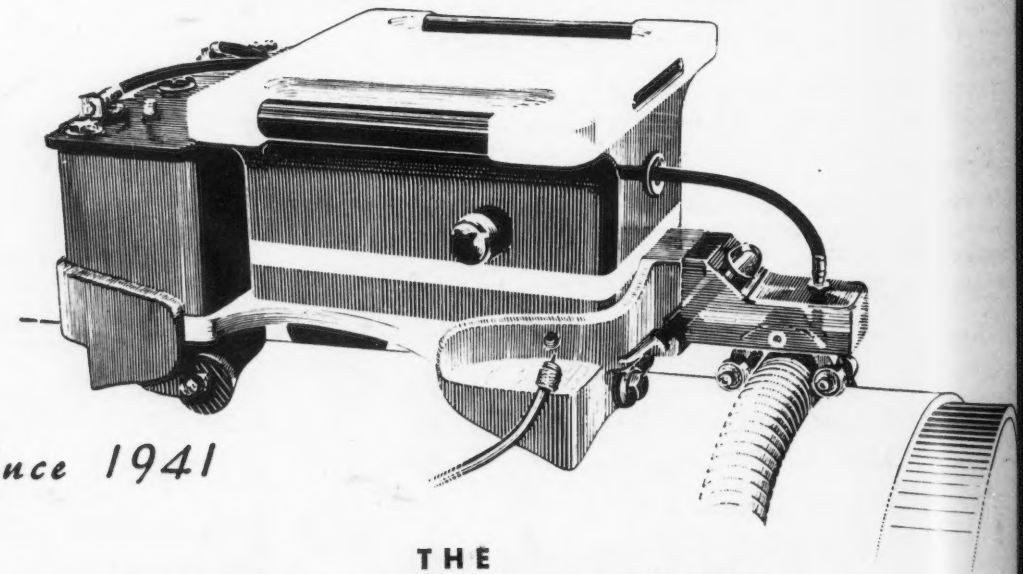

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